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Oceanographic Measurements in the Chuckchi Sea

April – August 1977

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by G.R. Garrison
M.L. Welch
J.T. Shaw

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ACKNOWLEDGMENTS

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I. INTRODUCTION

The 1977 oceanographic studies of the eastern Chukchi Sea are a continuation of marginal ice zone investigations conducted yearly since 1971 for the Arctic Submarine Laboratory. The earlier investigations have been described in several reports[1-5] and in the literature.[6] Considerable understanding has been obtained of the summer intrusion of warm water that enters through Bering Strait and moves northeasterly along the coast, eventually passing Pt. Barrow. The studies have also followed the springtime flow of the cold, higher-salinity water that drains northeasterly down the sloping Barrow Canyon and accumulates off the mouth; this water apparently forms in the shallow areas of the Chukchi Sea during winter freezing. Pockets of cold, highly saline water have been observed in the shallows along the coast. The 1977 studies provide additional data on these phenomena, and on the postulated surges[7] of Atlantic water from the Arctic Ocean onto the shelf.

Most of the information about the Chukchi Sea was obtained from temperature and salinity profiles, along with some water samples, taken from a helicopter resting on the ice at stations all along the coast and over the Barrow Canyon. The first survey was in April, followed by others in June and July. (A survey was also scheduled for May, but it was cancelled owing to the lack of helicopter support.)

Additional information was obtained at an ice camp established on shore-fast ice about 22 n.mi. (41 km) east-northeast of Barrow. The water depth was 15 m, great enough to experience oceanographic changes in the coastal waters. Conductivity-temperature-depth (CTD) profiles, water samples, current measurements, and weather observations were made routinely at the ice camp, both while it was stationary and after it had broken loose and was drifting westward across the Barrow Canyon. Photographs of the camp and surrounding area were taken by satellite, from a helicopter, and during the overflight of a Birdseye aircraft provided by the Naval Ocean Research and Development Activity (NORDA). A schedule of events is shown in Table I.

Table I. Summary of events, 1977.

April Oceanographic Survey	
9,10 April	Line B off Pt. Franklin
10 April	Line C off Pt. Barrow
13 April	Line A off Icy Cape
13 April	Line B off Pt. Franklin
15 April	Stations D2 and D4 northeast of Pt. Barrow
Establishment of Ice Camp APLIS	
16-19 May	Search in a Cessna for a suitable floe
20 May	Checked condition at a site east of Pt. Barrow using helicopter
20-23 May	Equipment and supply flights to the site by helicopter
25 May	A Cessna flight with equipment
June Oceanographic Survey	
9 June	Line E along open lead north of APLIS, Stations E1 to E5
10 June	Stations E6 and E7 northeast of APLIS
13 June	Stations E8 to E11 near Pt. Barrow
13 June	Stations C1 and C2 off Pt. Barrow
16 June	Lines B and C off Pt. Franklin
17 June	Line A off Icy Cape
27 June	Station E12 northeast of Barrow
Ice Camp APLIS	
23-24 June	Time Series (CTD) at APLIS
4 July	Time Series (CTD) at APLIS
9 July	Floe moved a small amount
13 July	Floe drifting into deeper water
July Oceanographic Survey	
13-16 July	Pt. Barrow, Line B (to northeast)
17 July	Pt. Barrow, Line C
13-19 July	APLIS stations while drifting across Barrow Canyon
Evacuation of APLIS	
18 July	Seven evacuation flights by helicopter
19 July	Seven evacuation flights by helicopter; personnel evacuated.
20 July	Four evacuation flights by helicopter; personnel returned to Barrow.
21 July	Two evacuation flights by helicopter. Two persons remained at APLIS when helicopter was grounded because of poor visibility.
22 July	Floe broke up. Fog lifted at noon and helicopter made a final evacuation of gear and personnel.
Icebreaker BURTON ISLAND Cruise	
24 July	Departed Nome for Bering Strait
28 July	Oceanographic Stations off Wainwright
5 August	Oceanographic Stations off Pt. Barrow
6 August	BURTON ISLAND disembarked scientific personnel at NARL

II. SUMMARY

Most of the phenomena observed in 1977 have been observed before, but the additional data gathered during these measurements allow a better understanding of the complex water exchange taking place in the vicinity of the Barrow Canyon. The major results of the 1977 measurements can be described as follows.

Changes in the Coastal Shallows: When ice freezes in shallow water, the displaced salts increase the salinity in the underlaying water masses. These heavier waters will, in time, settle down slope. The movement is so slow or so restricted that we observed salinities as high as 33.9‰ in 15 m of water (compared with 32.5‰ offshore).

This high-salinity water had warmed from near freezing (-1.8°C) to -0.5°C, indicating that the movement down slope is sufficiently slow that solar radiation warms the water appreciably. Other examples of considerable warming were observed beneath open leads.

Chukchi Sea Drainage: By April, the high-salinity water that is formed when the Chukchi Sea freezes begins to settle into the Barrow Canyon. During May and June, this water progresses along the shoreward side past Pt. Barrow to accumulate off the mouth of the canyon. At times it appears shoreward of a counterflow of warmer, lighter water separated by a steep isopycnal slope that could not remain for long unless the relative flow was quite high. This year the shoreward side of the canyon was filled to the surface with water that had a salinity greater than 33‰, often 2‰ higher than the water on the seaward side. By August, the drainage occupied a large area in the ocean beyond Pt. Barrow, between depths of 40 and 180 m.

Warm Water on the Shelf: Although the shallow Chukchi Sea cools to the bottom in the winter, warm layers (to -1.5°C) appear as far up the canyon as Pt. Franklin in April. This water has been traced northeastward to the temperature-maximum layer in the Arctic Ocean. Later, it appears at depths of 30-70 m on the seaward side of the canyon with higher-density drainage from the Chukchi Sea separating it from the coast. We do not know under what conditions or how fast this intrusion progresses, but we suspect that it is related to air pressure gradients across the region.

When open leads appear along the coast, usually in May, the water is warmed considerably by the sun. When Chukchi Sea drainage builds up along the shore and is then warmed under an open lead, the resultant water properties (temperature and salinity) often resemble those of Atlantic water. Several instances of water with such properties were observed, but in each case surface warming appeared to be a better explanation than a surge of Atlantic water.

Surges of Atlantic Water: Water with the same temperature and salinity as Atlantic water was observed in the Barrow Canyon 50 m above the normal depth of the same type of water in the Arctic Ocean. This water was traced sufficiently far down the canyon to leave no doubt that it was Atlantic water that had progressed up the canyon. The movement may have been slow (weeks) or in the form of a surge (days).

Water with a temperature and salinity similar to those of Atlantic water arrived at the ice camp along the shore-fast ice east of Barrow coincident with southerly currents and low air pressure. Analysis of the oxygen content of this water showed some low values similar to samples taken from the deep layer of Atlantic water in the Arctic Ocean; however, the spread in the results for samples from the same bottle was so great that these values must be considered unreliable. The samples that did produce consistent results showed a high oxygen content and thus are evidence against a surge of water from the Arctic Ocean.

III. ICE CAMP APLIS

The ice camp was established primarily for acoustic studies. However, oceanographic instrumentation was installed and operated routinely to determine the character of the acoustic medium and to study the water exchange in the area.

Search for a Floe

The intent was to establish APLIS on an old floe about 50 miles west of Pt. Barrow. However, a search for several days with a Cessna 180 did not reveal any floe of sufficient thickness to support a camp for a 3-month period. In desperation, the shore-fast ice that clings along the coast east of Pt. Barrow was examined. A few old floes thick enough to survive the summer were observed within the pack, distinguishable by their uneven surface of greenish hard ice. The Cessna was landed near one of the floes, and holes were drilled through the ice to check the ice thickness and water depth. There appeared to be 2-3 m of ice overlaying 15 m of water, which was considered acceptable. The next day we returned and selected a site for the camp buildings. Because of the difficulty in leveling the irregular surface of the old floes, we chose to set the structures on the flat frozen melt ponds. Later in the summer as the melt ponds encroached on the camp, we regretted that we hadn't somehow erected the huts on the thicker hummocks.

Camp Facilities

The camp structures consisted of four wooden 8 x 12 ft huts which had been prefabricated in 4 ft x 8 ft sections at NARL and flown to the site slung beneath a helicopter. The huts were made of 2 x 3 in. studding, plywood, and fiberglass insulation. They were outfitted as a generator shed, a mess hall, an acoustic laboratory, and an ice-physics laboratory. Tents were provided for the head, and for a rotating acoustic projector/receiver. The laboratories doubled as bunk rooms. The arrangement on the floe is shown in Figure 1; the upper photograph was taken near the beginning of the melt season and the lower one was taken shortly before the breakup of the floe. The CTD profiler and the current meter were operated in the generator shed. The weather sensors were mounted 5 m above the roof of the mess hall.

Power was supplied to the camp by a 5-kVA diesel generator set up to use JP5 helicopter fuel. The fuel tank was supported on the outside of the shed. The buildings were heated with 20,000 Btu/h propane heaters.

The CTD profiler was a lightweight hand-operated unit.[8] The sensors consisted of a thermistor, conductivity cell, and Digiquartz pressure sensor. The winch was attached to the wall of the generator shed over a 41-cm hole in the floor which extended through the 3-m thick ice below.

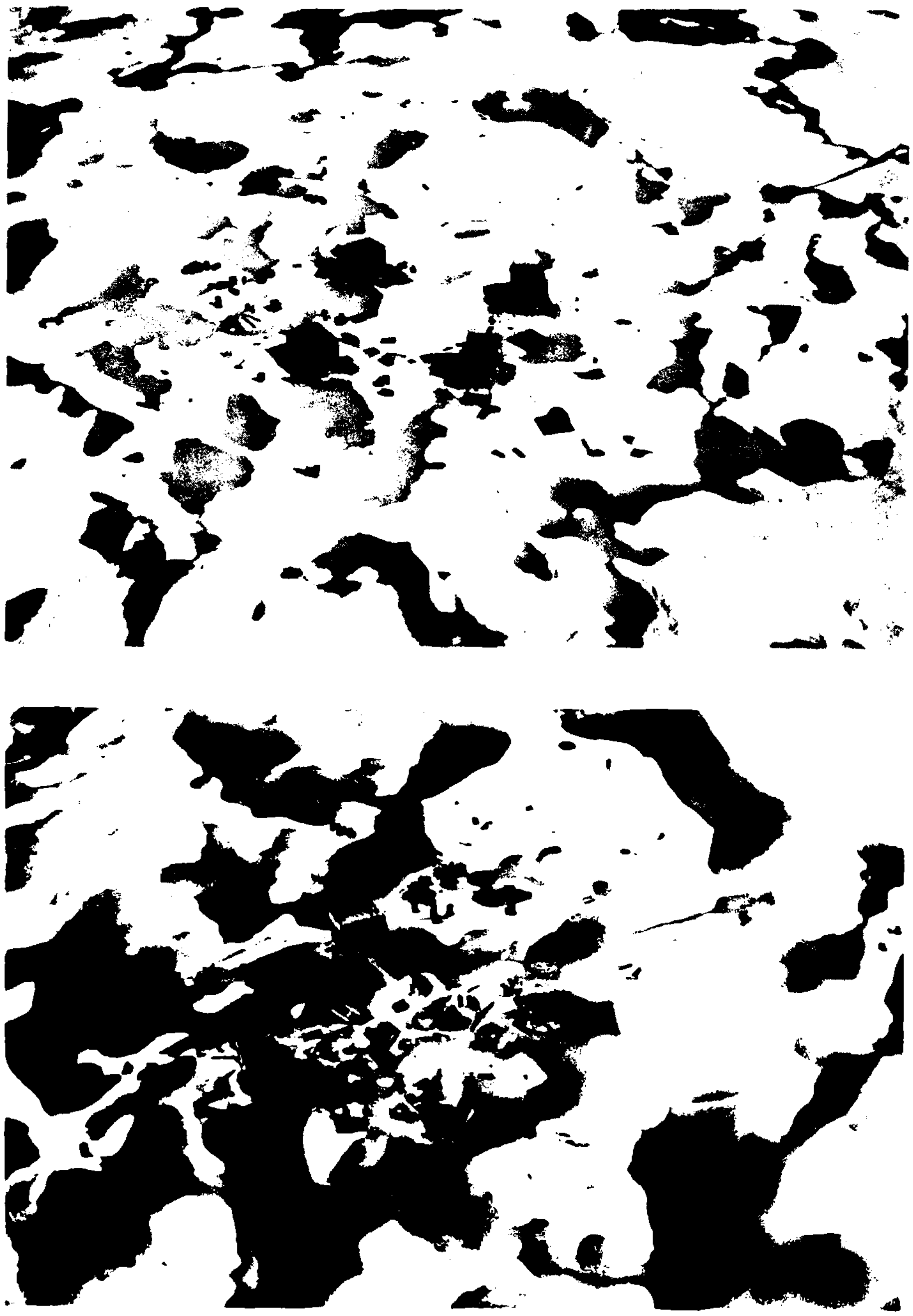


Figure 1. Ice camp APLIS in summer 1977. Upper view is in late June; lower is just prior to breakup on 19 July. (Courtesy of John Bitters, NARL.)

Aerial Photographs

Photographs of the area surrounding the ice camp were made from five platforms: a National Oceanic and Atmospheric Administration (NOAA) satellite, a LANDSAT satellite, a Birdseye aircraft, a helicopter or Cessna, and the camp itself.

The NOAA satellite provided at least daily coverage of the area. Prints of both photographs and infrared images were obtained from the National Environmental Satellite Service at the Gilmore Creek Observatory near Fairbanks, Alaska. A group of these photographs taken at about 2-week intervals is presented later.

The LANDSAT satellite operated by the National Aeronautics and Space Administration provided a more detailed view of the area near Pt. Barrow. Figure 2 shows the shore-fast ice east of Pt. Barrow and the approximate location of the camp. The open water to the north is very evident, and important to the study.

A Birdseye overflight by the Naval Ocean Research and Development Activity provided low-altitude photographs of the camp and surroundings. APL personnel returning to the ice camp by helicopter often had good opportunities to photograph the camp area.

Floe Drift

A transmitter for tracking the floe provided signals to a Navy NIMBUS satellite that passed over in polar orbit several times a day. The data received by the satellite were re-transmitted to a station in Maryland where they were processed to determine the position of the ice camp. These positions were sent by telephone to NARL and relayed by radio to APLIS.

There was no evidence in the data during June and early July of any floe movement. The scatter in the data was equivalent to a standard deviation of about 2 n.mi. (3.6 km). On 9 July, the satellite data indicated an easterly movement of 6 n.mi. (11 km) after which the floe appeared to stop. On 13 July, the floe started moving northwestward; the water depth increased, and the floe began a drift which carried it 50 n.mi. (93 km) west of Pt. Barrow before it broke up (see photograph in Figure 3). The track obtained from the satellite data, with much of the jitter smoothed out, is shown in a later section. There was an indication of drift-speed variations, but the positional data were too poor to correlate these variations with tidal effects or to determine the absolute currents at the camp.


APLIS (APPROX)
PT. BARROW

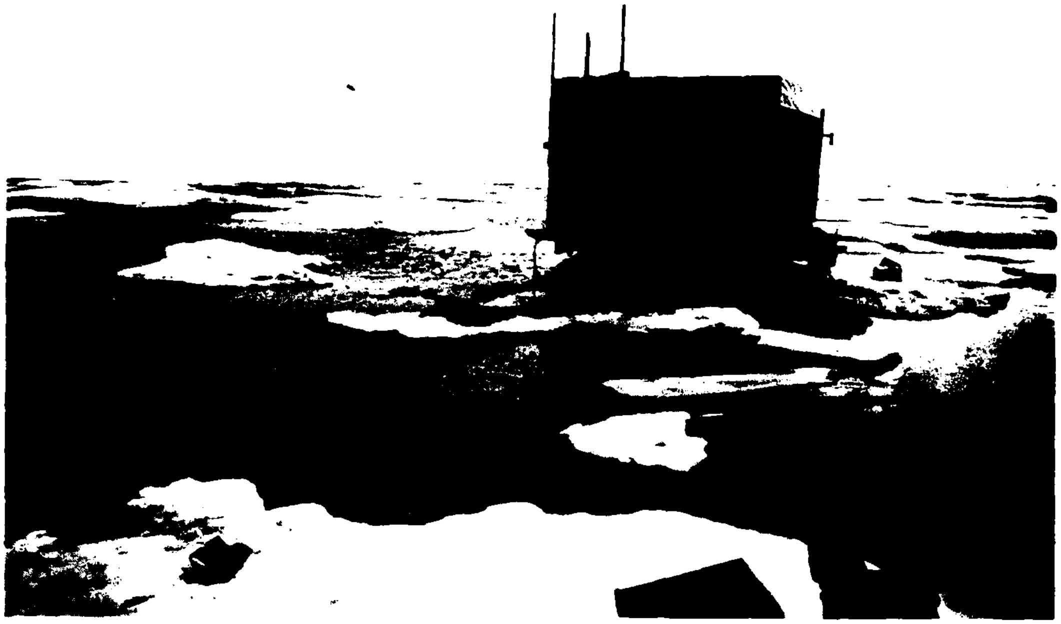


Figure 3. The breakup of APLIS in late July.

IV. MEASUREMENTS

The oceanographic surveys off the coast were conducted by helicopter. The positions of the stations were determined by dead reckoning. Occasional checks were made by flying the helicopter high enough for one of the coastal radar stations to obtain a fix, and the range and bearing from the radar station were radioed to the helicopter immediately. Using this method to locate the outer end of a line of stations greatly increased the positional accuracy of the intermediate stations along the line.

After landing, a hole was augered through the ice and the probe of the APL lightweight hand-operated CTD profiler was slowly lowered to the bottom. Data were tape recorded as the probe was both lowered and raised.

Water samples were taken by attaching a plastic sampling bottle to the CTD cable. Weather and current measurements at the camp were taken with standard equipment. Satellite photographs were requested during the period that the camp was occupied.

April CTD Profiles off the Coast

The locations of the stations for the April survey are shown in Figure 4. The arrows at some of the stations indicate the relative direction of the current as determined from the angle of the cable when raising and lowering the probe. For stations D2 and D4, the navigation was so poor that the position has been indicated by a large circle. The individual profiles are shown in Appendix A.

Before April the eastern Chukchi Sea was ice covered. A slight opening occurred along the coast in March as the entire ice pack moved southwestward. A satellite photograph taken on 13 April, the day the survey started, shows an extensive crack along the coast in what appears to be fairly thick ice. The CTD operator reported ice thicknesses exceeding 2 m in this vicinity.

In the following figures, the cross section of each line of stations perpendicular to the coast has been plotted twice, once with isothermals and once with isohalines. Shadings have been used to emphasize an isothermal region near the surface, temperatures above -1.5°C, and salinities above 32.5‰.

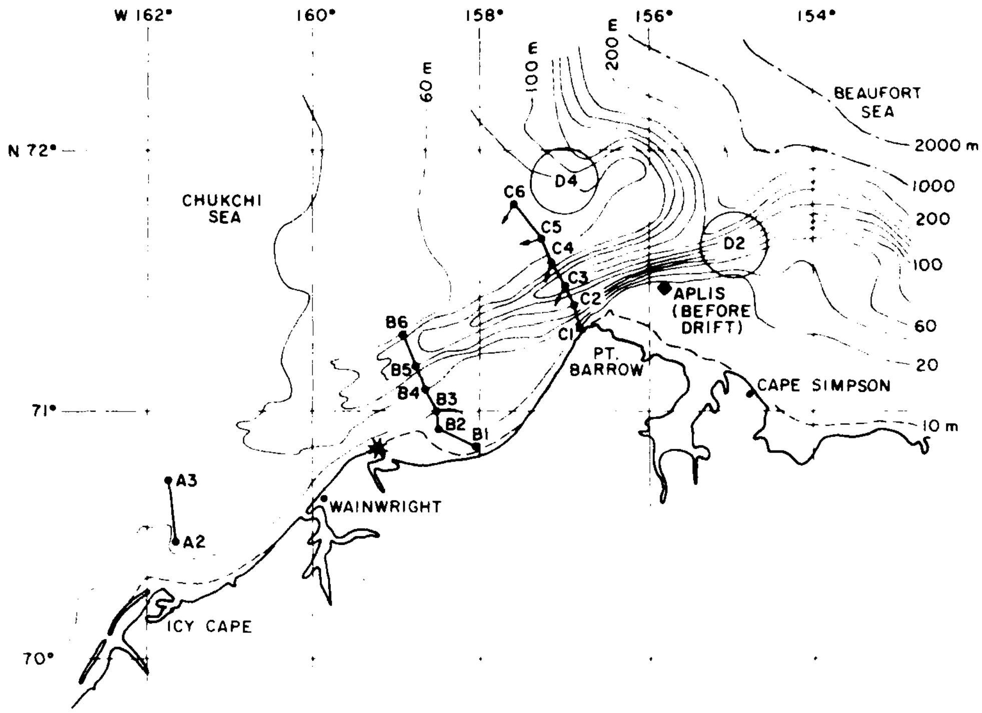


Figure 4. Location of stations for the April survey. ✱ indicates Pt. Franklin; arrows indicate direction of current.

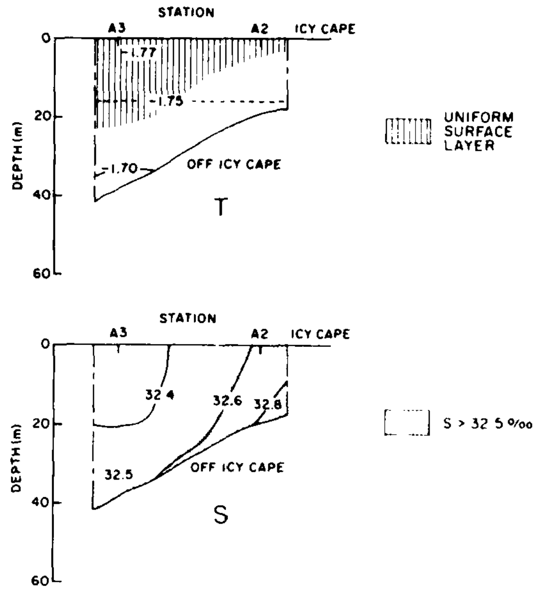


Figure 5. Sections for Line A off Icy Cape on 13 April 1977.

The southernmost stations, A2 and A3 off Icy Cape, are shown in Figure 5. There is a large surface layer of uniform water (-1.77 to -1.75°C; 32.4 to 32.6‰) extending as deep as 20 m. Beneath this layer, the salinity increases, with the highest value (32.8‰) close to shore. Apparently freezing during the past month had increased the salinity in the shallower water and this heavier water had not reached an equilibrium with the lighter water farther from shore.

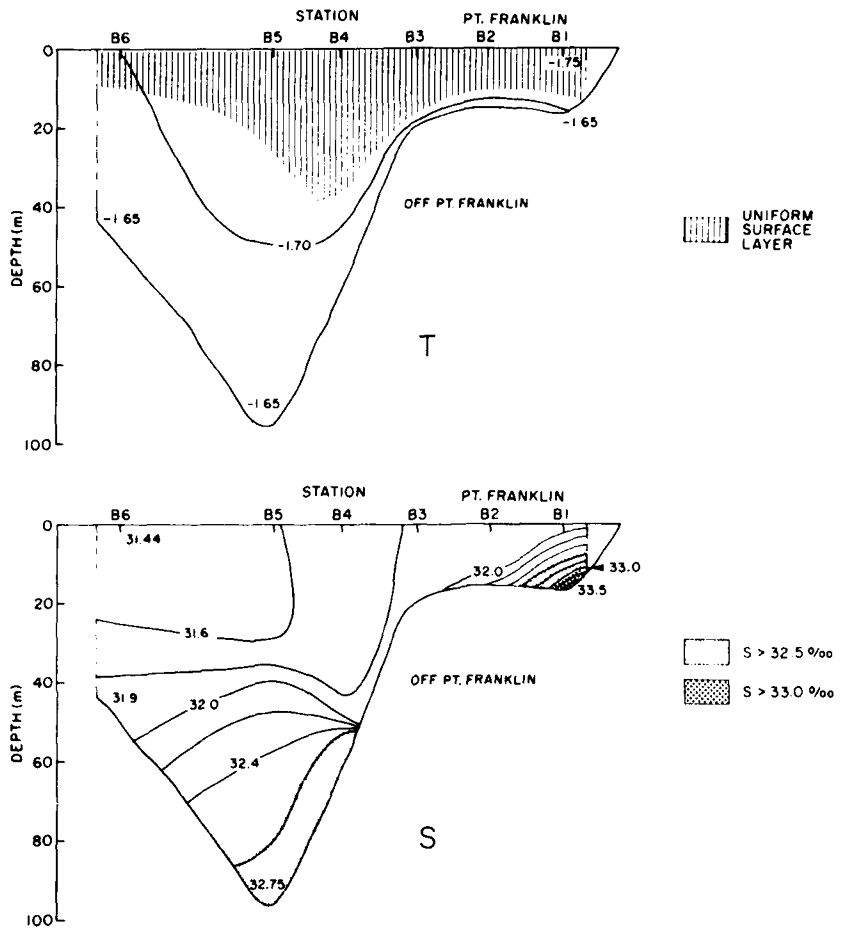


Figure 6. Sections for Line B off Pt. Franklin on 13 April 1977.

The sections for Line B off Pt. Franklin on 13 April (Figure 6) also show a surface layer of uniform water, but the layer is slightly warmer and less saline than off Icy Cape. Again, the salinity is higher near shore with a 33.5‰ pocket (at stations B1 and B2) that seems to be of slightly higher temperature. This section crosses the upper end of the Barrow Canyon. Along the shoreward edge of the canyon is a uniform layer (shaded) of near-freezing water with salinity above 32.5‰ that we have previously referred to[6] as a "drainage" of high-salinity water from the shallow areas of the Chukchi Sea into the Arctic Ocean via the Barrow Canyon.

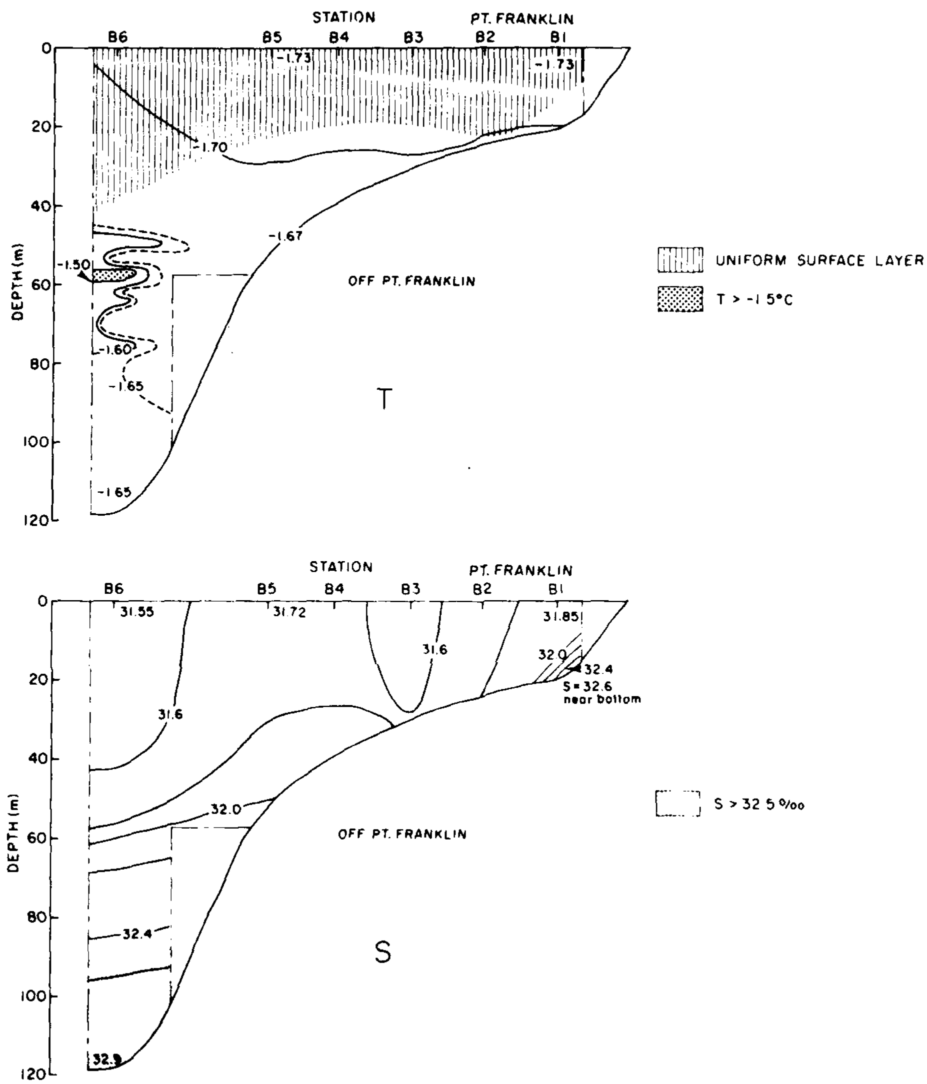


Figure 7. Sections for Line B off Pt. Franklin on 9 and 10 April 1977.

The sections for a line taken off Pt. Franklin 4 days earlier (apparently farther northeast because the canyon is deeper) are shown in Figure 7. The conditions in the deeper portions are surprisingly different. The slope of the isohalines is not known because of the large spacing between stations B5 and B6. The appearance of warmer water (to -1.5°C) at 60 m seems unusual; this water is not related to water farther west or it would have appeared in Figure 5 or Figure 6.

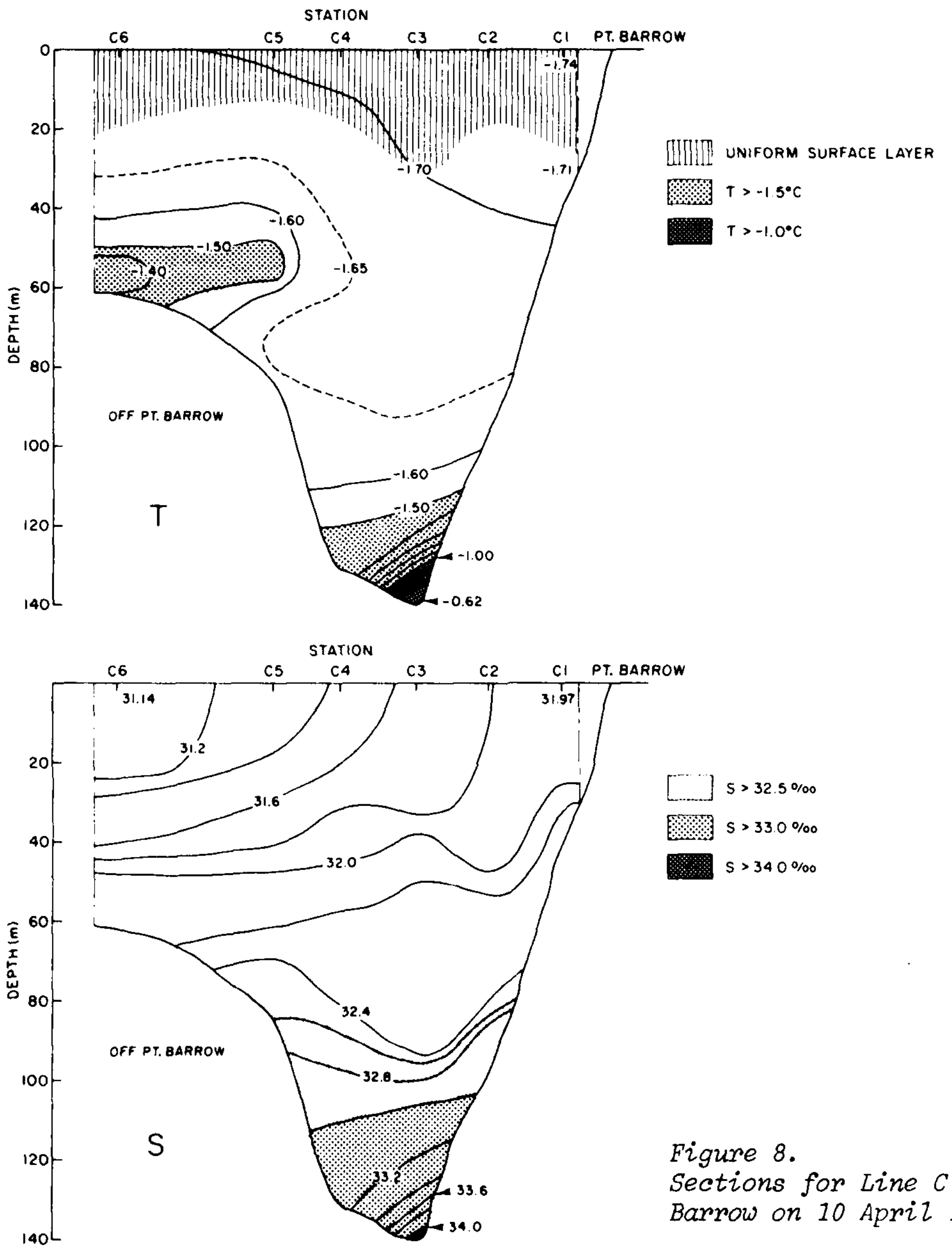


Figure 8.
Sections for Line C off Pt. Barrow on 10 April 1977.

The sections for a line taken off Pt. Barrow on the same date (Figure 8) show more of this warmer water, this time at two depths--60 m and 120 m. The upper layer is well off the coast along the top of a submerged ridge that juts into the ocean. The lower layer is in the transition to Atlantic water, which has a salinity exceeding 33‰. At the very bottom of the canyon, at a depth of 140 m, the Atlantic water reaches -0.6°C and 34‰. These measurements were made on 10 April, and the previous winter would have cooled water at 60 m to the freezing point. The -1.5°C water at 60 m must have recently arrived.

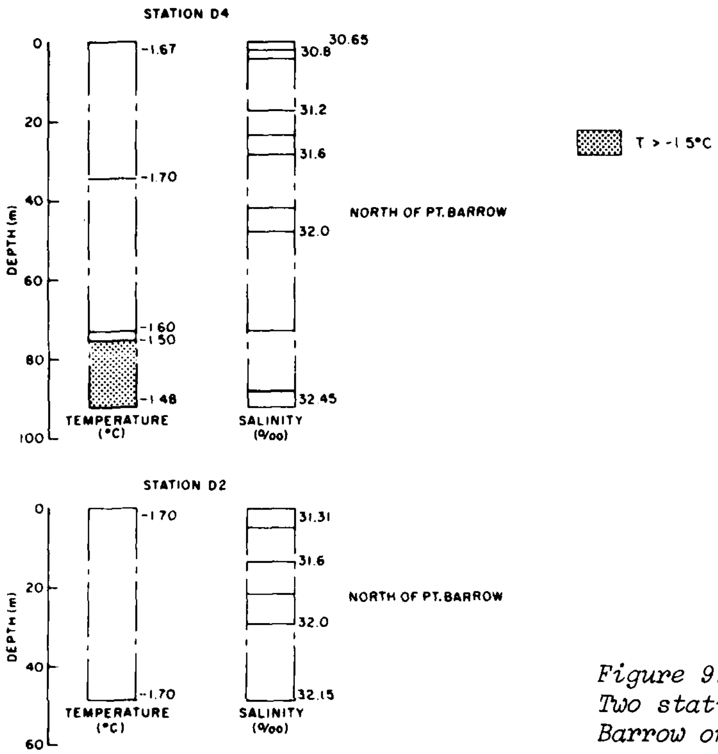


Figure 9.
Two stations north of Pt. Barrow on 15 April 1977.

Two more stations, D2 and D3, were taken in April, but their positions were not accurately determined. The conditions at these stations are shown in Figure 9. At station D4, the maximum temperature occurs at 90 m, somewhat intermediate in depth between the two layers shown in Figure 8. Station D2 shows a uniformly cold layer to 50 m.

June CTD Profiles off the Coast

A similar survey was conducted in June. The locations of the stations are shown in Figure 10 and the profiles appear in Appendix B. The satellite photographs showed a 20-mile wide strip of open water along the coast during most of May. The considerable surface warming in the sections for the Icy Cape line, Figure 11, demonstrates the result. These stations are closer to shore than those in April, which may be one reason for the higher salinity. Another reason may be an increase due to continued freezing in the latter half of April. Although there is considerable warming on the surface, note that the highest temperature (-0.5°C) occurs along the bottom where the salinity is also highest (33.9‰). It appears that the high-salinity water remaining after the winter's freezing has been warmed. An alternate possibility is that it results from a surge of Atlantic water up the sloping canyon. However, this is considered unlikely because none of this water was observed farther down the canyon (see following sections).

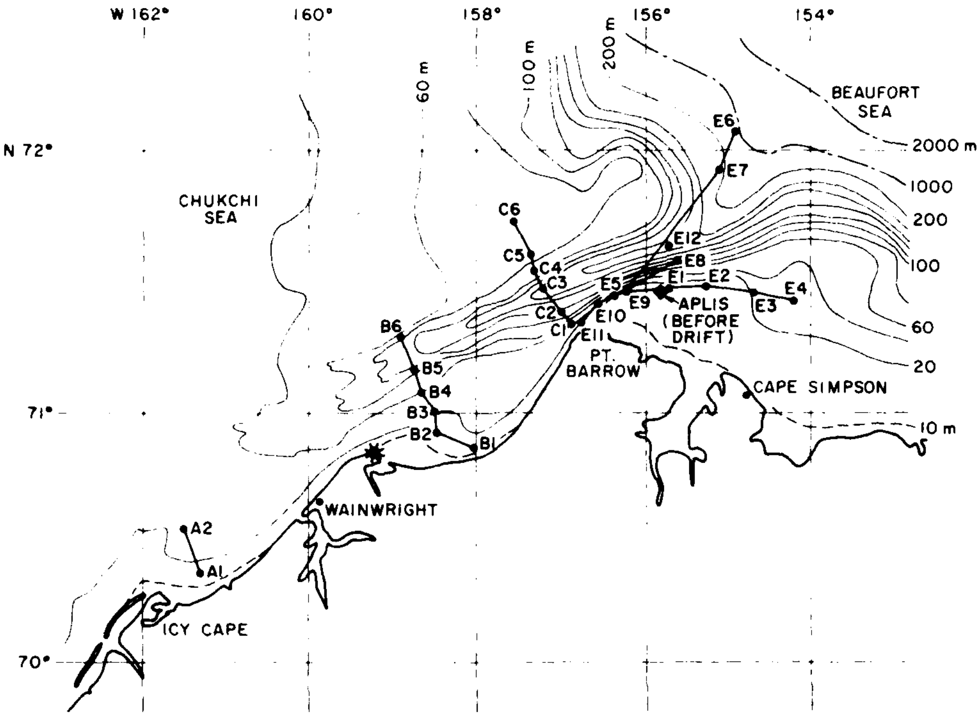


Figure 10. Location of stations for the June survey.
✱ indicates Pt. Franklin.

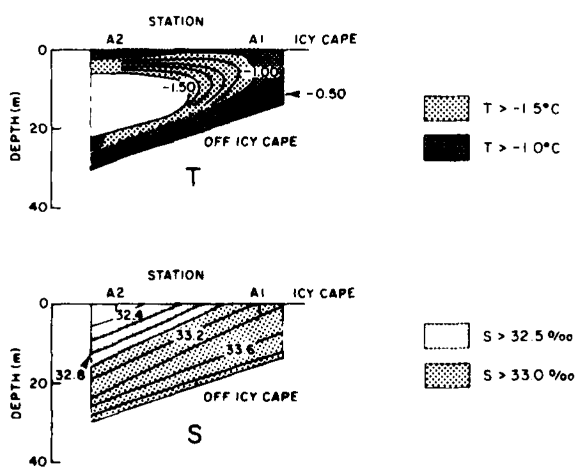


Figure 11. Sections for Line A off Icy Cape on 17 June 1977.

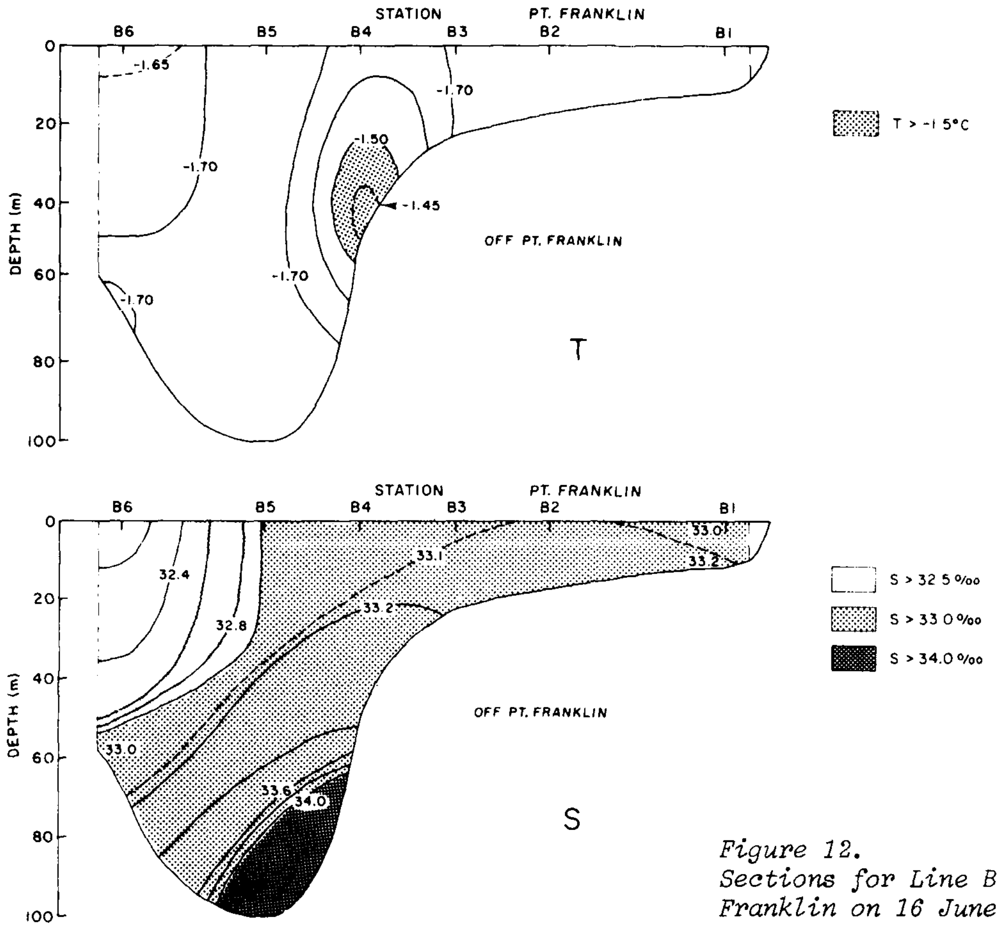


Figure 12.
Sections for Line B off Pt. Franklin on 16 June 1977.

The sections for Line B off Pt. Franklin (Figure 12) show a pocket of warm water at station B4 surrounded by cold water. We have carefully checked for a possible error. These values appeared as the probe was both lowered and raised, and the cold temperature near the surface indicates that the whole curve is not merely shifted. There seem to be two water masses at station B4: in the upper 20 m, water with a temperature of -1.60°C and a salinity of ~ 33.1‰; in the lower 30 m, water with a temperature of -1.45°C and a salinity of 33.3‰. The lower water has properties similar to the water shown near shore in Figure 11; however, the distance from Line A to Line B is approximately 70 n.mi. (130 km), and the movement of this warm water in either direction seems unlikely. The high salinity values and the slope of the isohalines indicate that the water with salinity above 33.0‰ is drainage from the shallow portions of the Chukchi Sea which is moving along the coast toward the ocean. The isolated pocket of water must be from solar heating at the open lead along the shore in May (see the satellite photograph in Figure 42, p. 58).

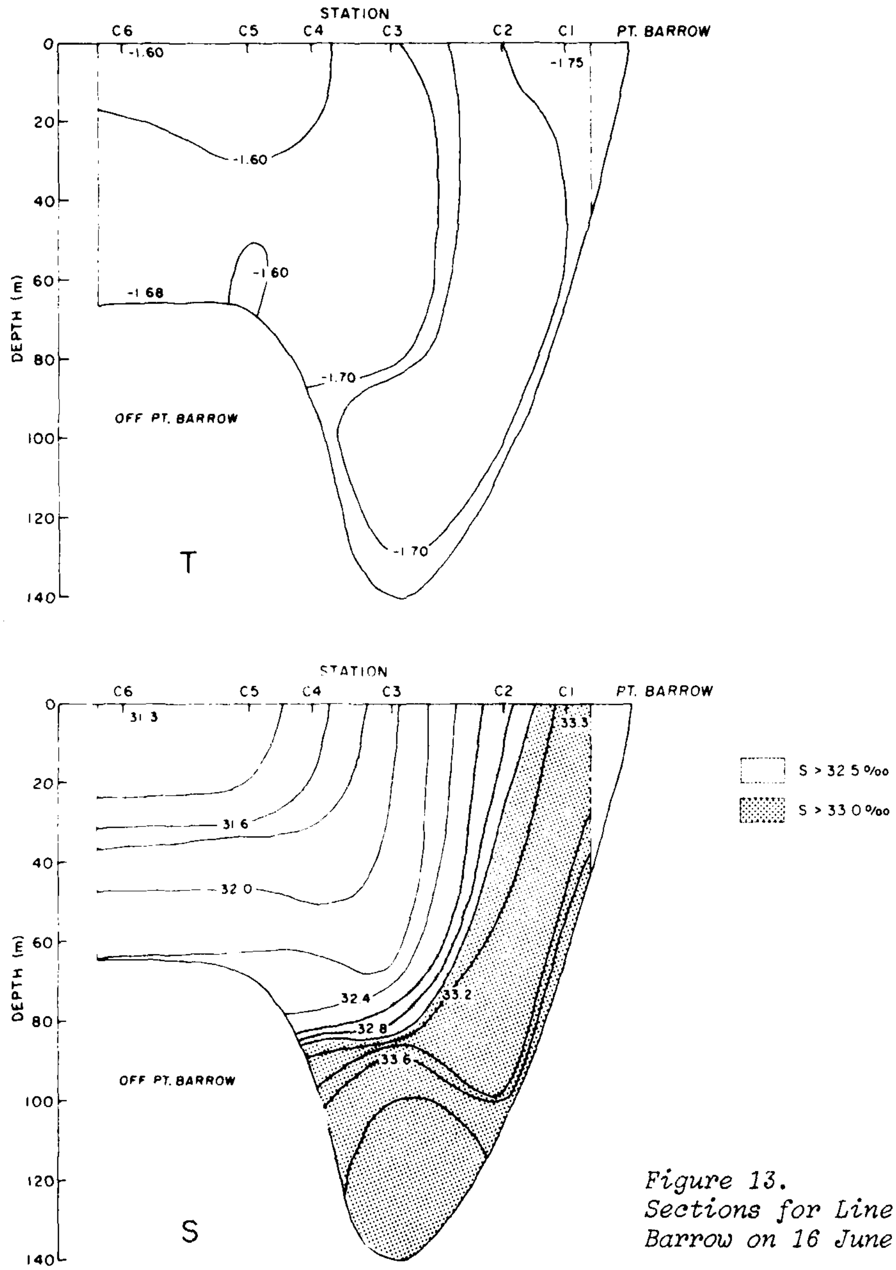


Figure 13.
Sections for Line C off Pt. Barrow on 16 June 1977.

At station C6 off Pt. Barrow (Figure 13), the water near the surface is slightly warmer (to -1.60°C), but at a low salinity (31.3‰). Note the slope to the isohalines, with a salinity as high as 33.6‰ at 50-m depth. Measurements were also taken at stations C1 and C2 3 days earlier; in those 3 days, the salinity decreased some 0.4‰ in the lower portions of stations C1 and C2, indicating a movement of the Chukchi water northeastward through the canyon from station B5.

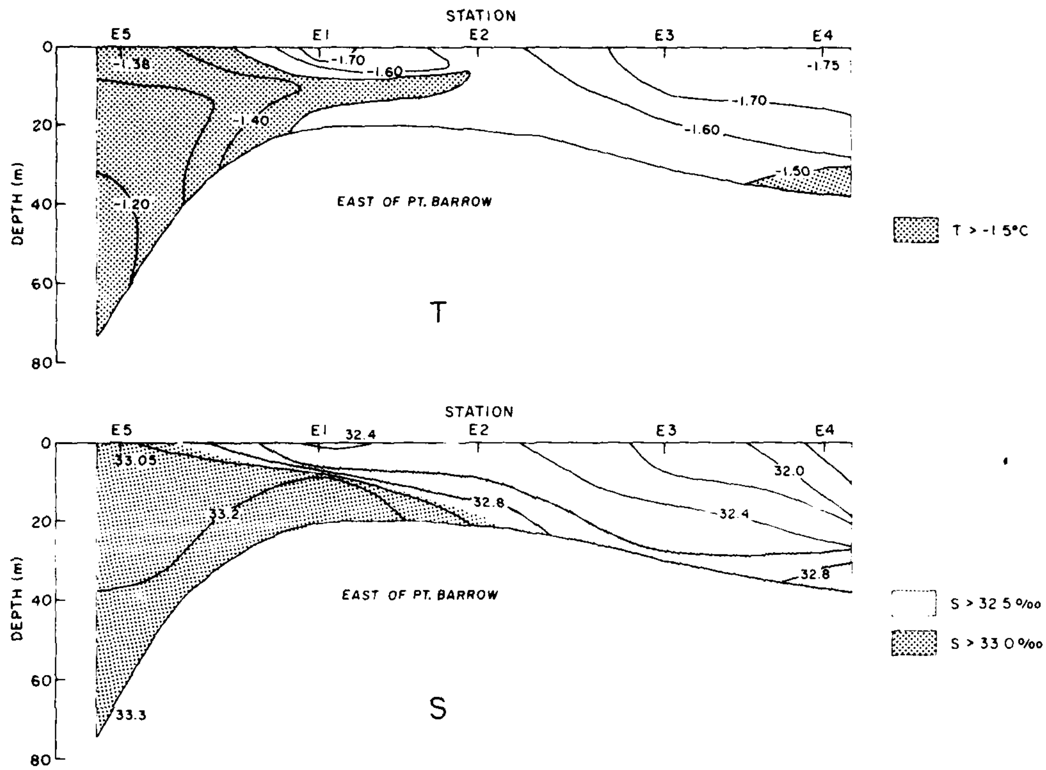


Figure 14. Sections along the ice edge north of APLIS on 9 June 1977.

Figure 14 presents sections for profiles taken on 9 June along the edge of the shore-fast ice supporting APLIS (see map in Figure 10). Here the salinity is higher at the west end than at the east end of the section (above 33.0‰ through the entire water column at station E5). This high-salinity water is also accompanied by high temperatures (as warm as -1.2°C at station E5). The similarity in salinity to stations along the coast (B1-B4, and C1) indicates that this would be the forefront of the movement of Chukchi Sea water into the Beaufort Sea. The warmth could be due to surface warming at the open lead along the coast, but the occurrence of the highest temperature at depth appears unusual. On the other hand, could a surge have brought warm Atlantic water to the surface?

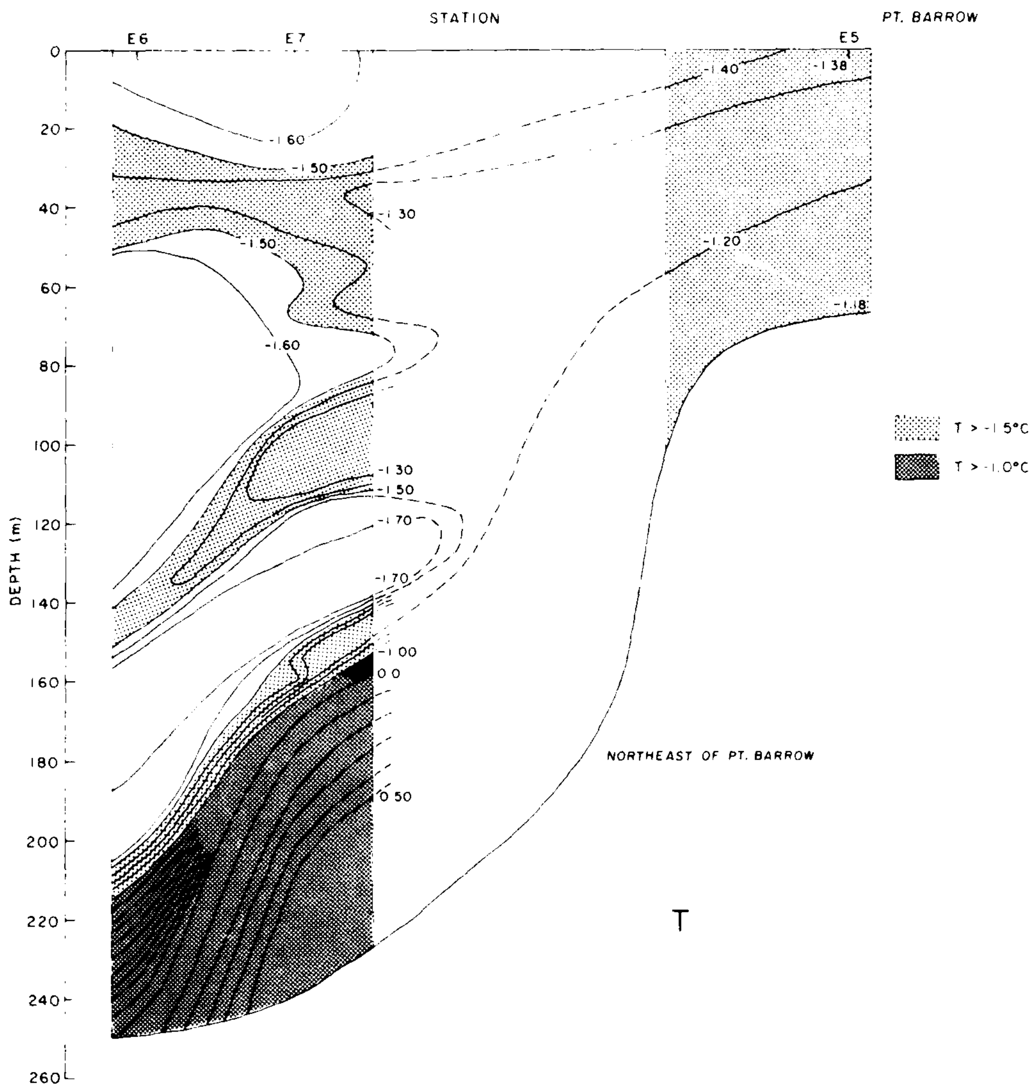


Figure 15a. Sections northeast from Pt. Barrow, 9 and 10 June 1977. Dashed lines are estimates in a region with no data.

The next day, stations E6 and E7 were occupied to search for the source of the warm water in that direction. Although there was considerable distance between stations E7 and E5, there appears to be a possible transition, as shown in Figure 15. The up-slope of Atlantic water from station E6 to station E7 could extend to station E5, indicating the possibility that the high salinity and warm temperatures observed at station E5 are the result of an uprising of Atlantic water. Some of this water may have dropped back (station E7 at 110 m) above a tongue of Chukchi water, after mixing with shallower water and becoming less saline.

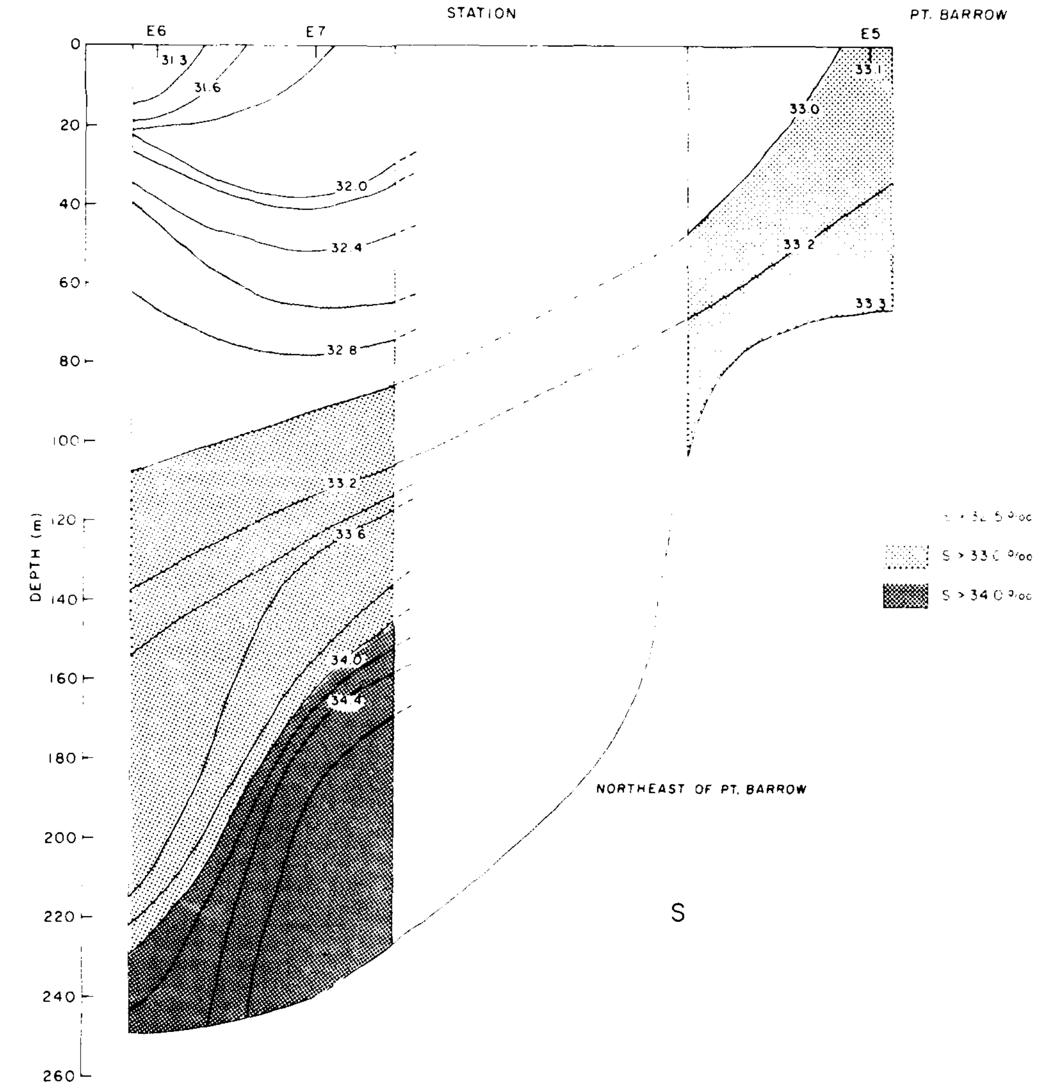


Figure 15b. Sections northeast from Pt. Barrow, 9 and 10 June 1977. Dashed lines are estimates in a region with no data.

Three days later, stations E8 to E11 were occupied to determine the direction of the possible uprising (see Figures 10 and 16). The low temperature (-1.7°C) at stations E8 to E11 precludes an uprising from northeast or southwest.

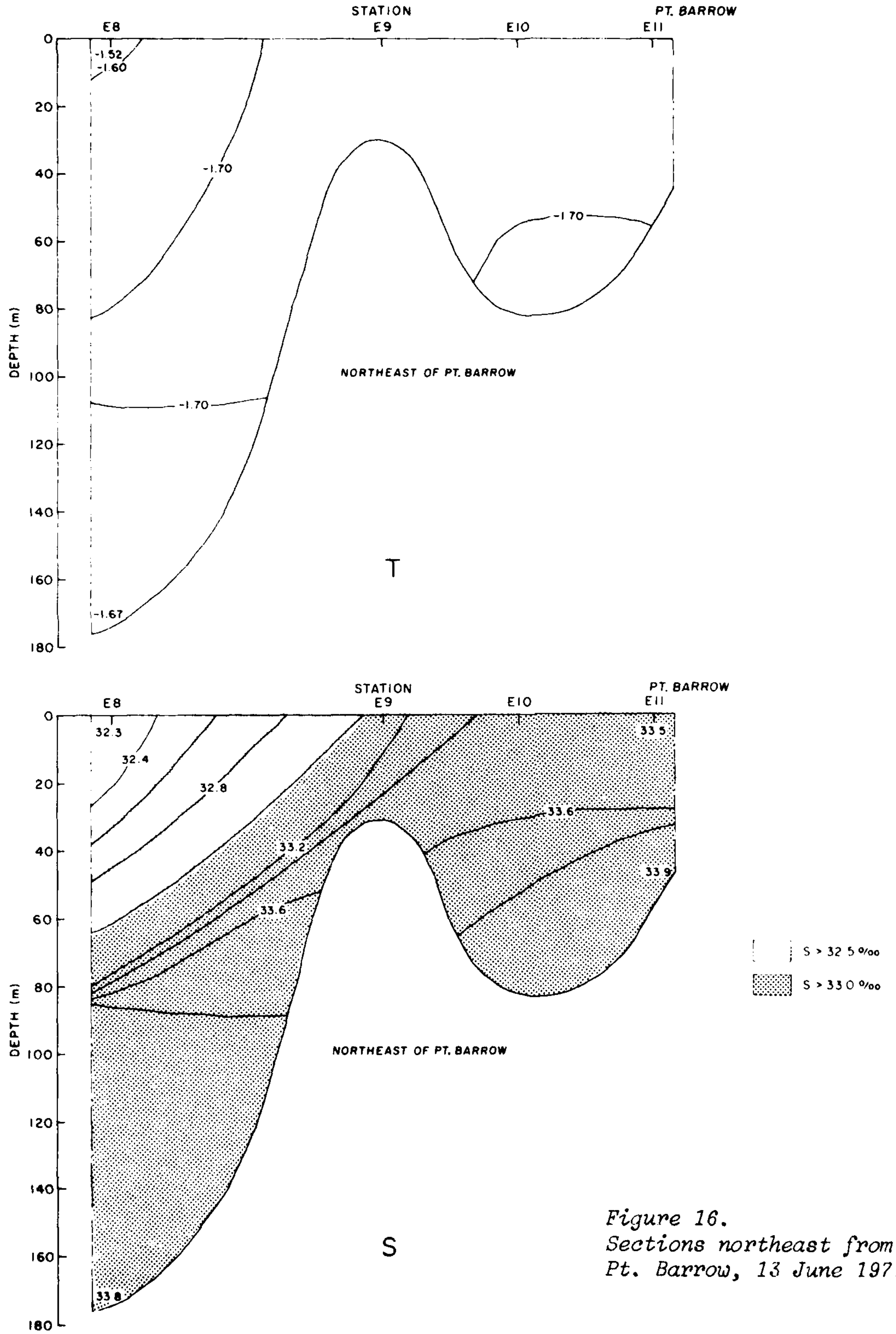


Figure 16.
Sections northeast from Pt. Barrow, 13 June 1977.

Any surge from station E7 to station E5 would have to progress up the axis of the canyon, and approach E5 from the north rather than in a straight line. Perhaps the 3-day time difference or the inaccuracy in positioning produces some discrepancies. Observations of the cable angle during the profiling showed a very strong northerly current at station E8, no current at the shallow station E9, and medium currents to the northeast at stations E10 and E11, thus giving evidence against an uprising from the north. Solar warming appears to be a better explanation for the warm water at station E5.

On 27 June, a single, inaccurately located station (E12) was occupied. Shaded plots of the results are presented in Figure 17 for

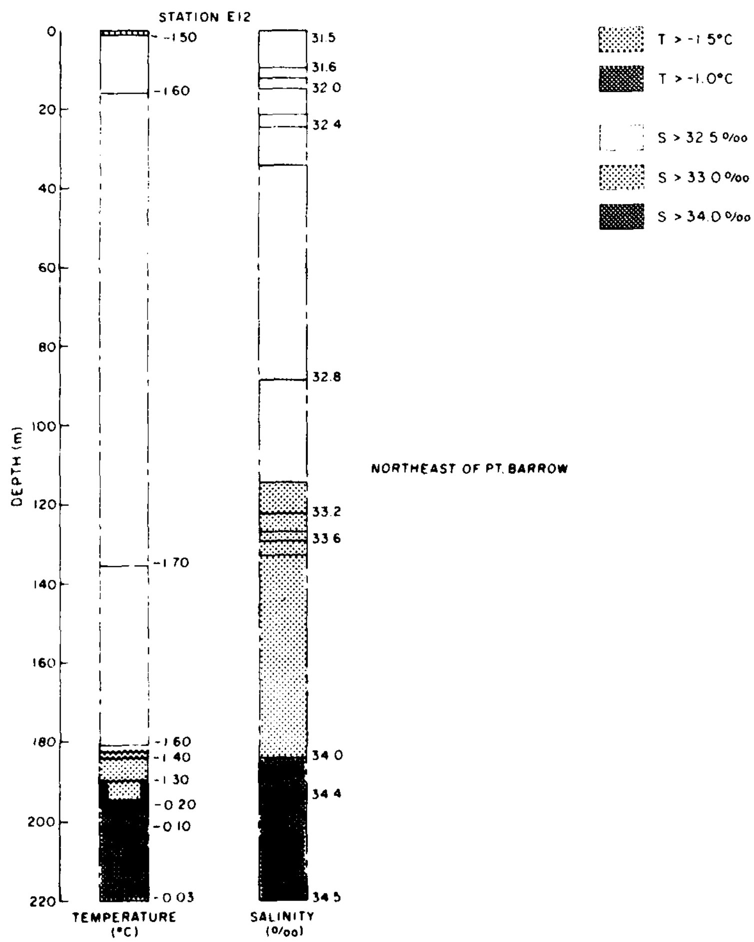


Figure 17. A station northeast of Pt. Barrow, 27 June 1977.

comparison with the other sections. Figure 17 shows the presence of warm, saline Atlantic water at depth and a large accumulation of cold drainage from the Chukchi Sea at 135 to 185 m. Above this, a new, cold layer at 45 to 110 m with a salinity of 32.8‰ has formed. This new layer must be a more recent movement of Chukchi Sea water into the Arctic Ocean.

July CTD Profiles off the Coast

Oceanographic conditions off Pt. Barrow were checked again in mid-July (see map in Figure 18 and Appendix C). Figure 19 shows the sections for Line B to the northeast along with station 521 from the drifting ice camp.

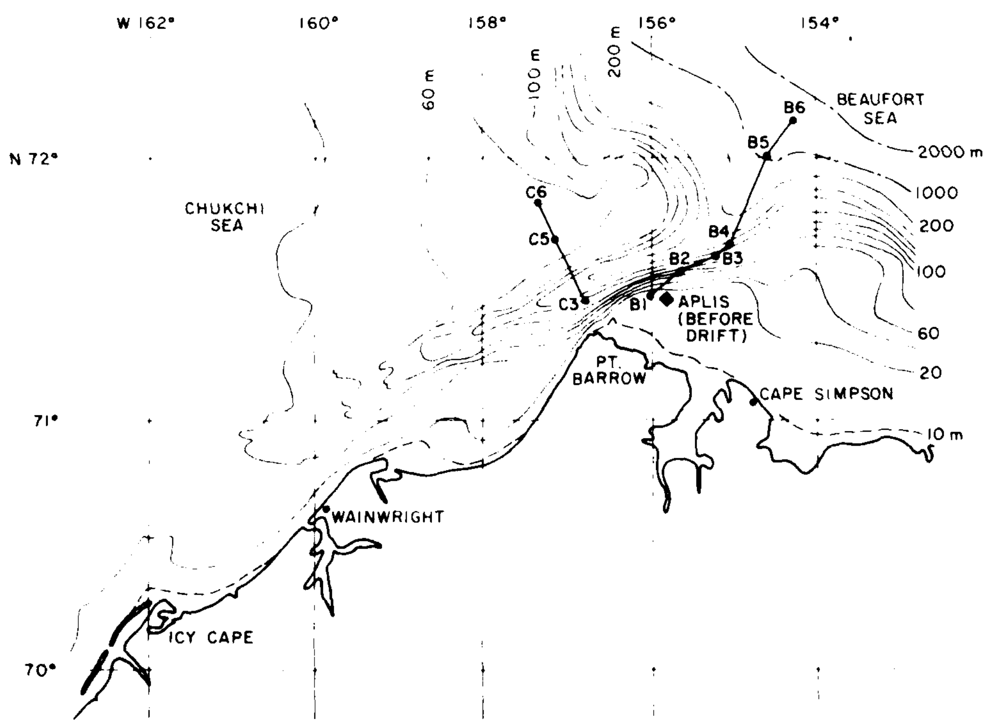


Figure 18. Location of stations for the July survey.

Station B2 contains a pocket of very warm water (-1.0°C) which is the forefront of the intrusion from Bering Strait, which became as warm as 7°C in this vicinity on 5 August. There now appear to be two layers of uniform water, one with T = -1.6°C and S = 32.8‰ between 50 and 70 m and one with T = -1.6°C and S = 33.6‰ between 120 and 140 m

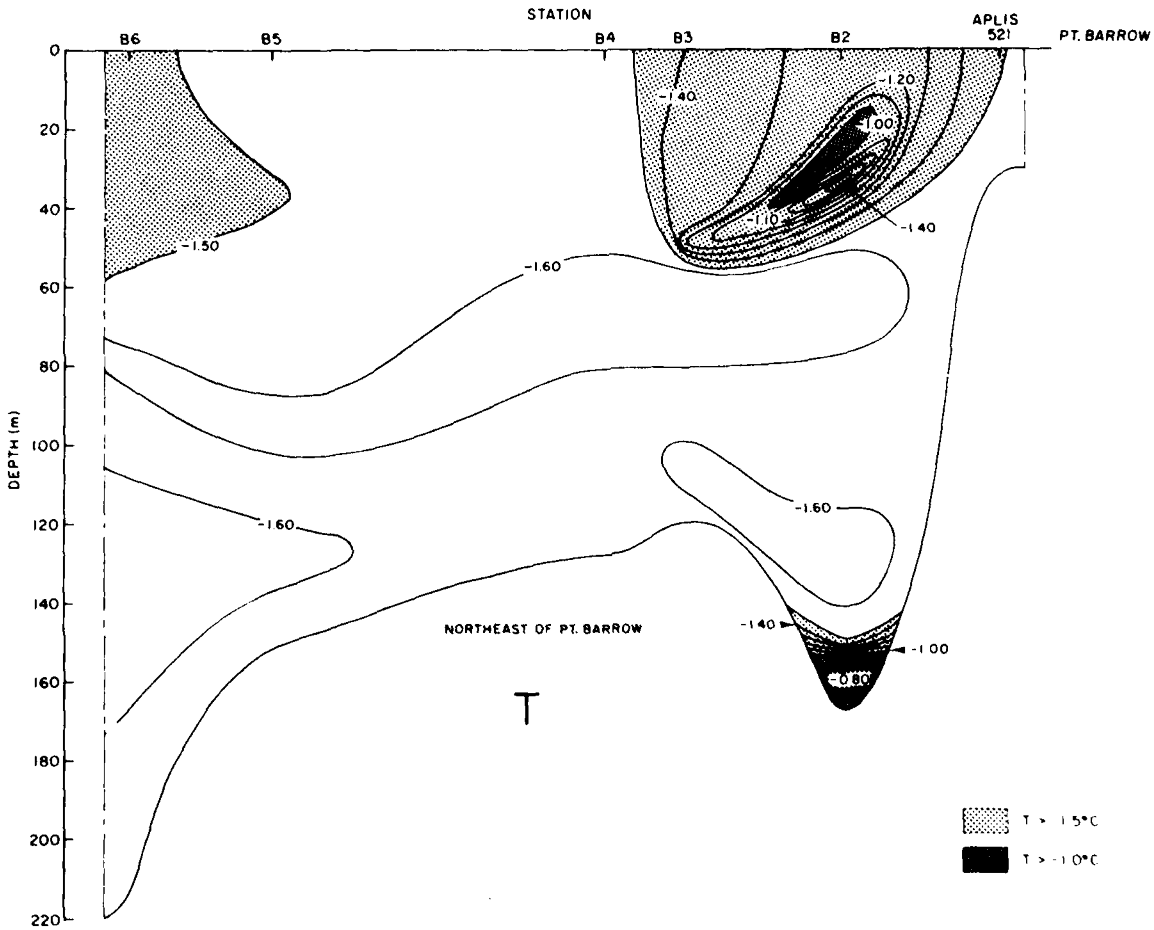


Figure 19a. Sections for Line B northeast from Pt. Barrow on 13-16 July 1977; also shown is station 521 from Ice Camp APLIS, which had just started its drift westward across the Chukchi Sea.

(see the profiles in Appendix C). At station B2, which is nearest the center of the canyon, a layer with T = -1.5°C and S = 33.2‰ appears between these two layers; this layer may be the most recent because it is the most uniform. The rise in the isohalines near shore is still pronounced.

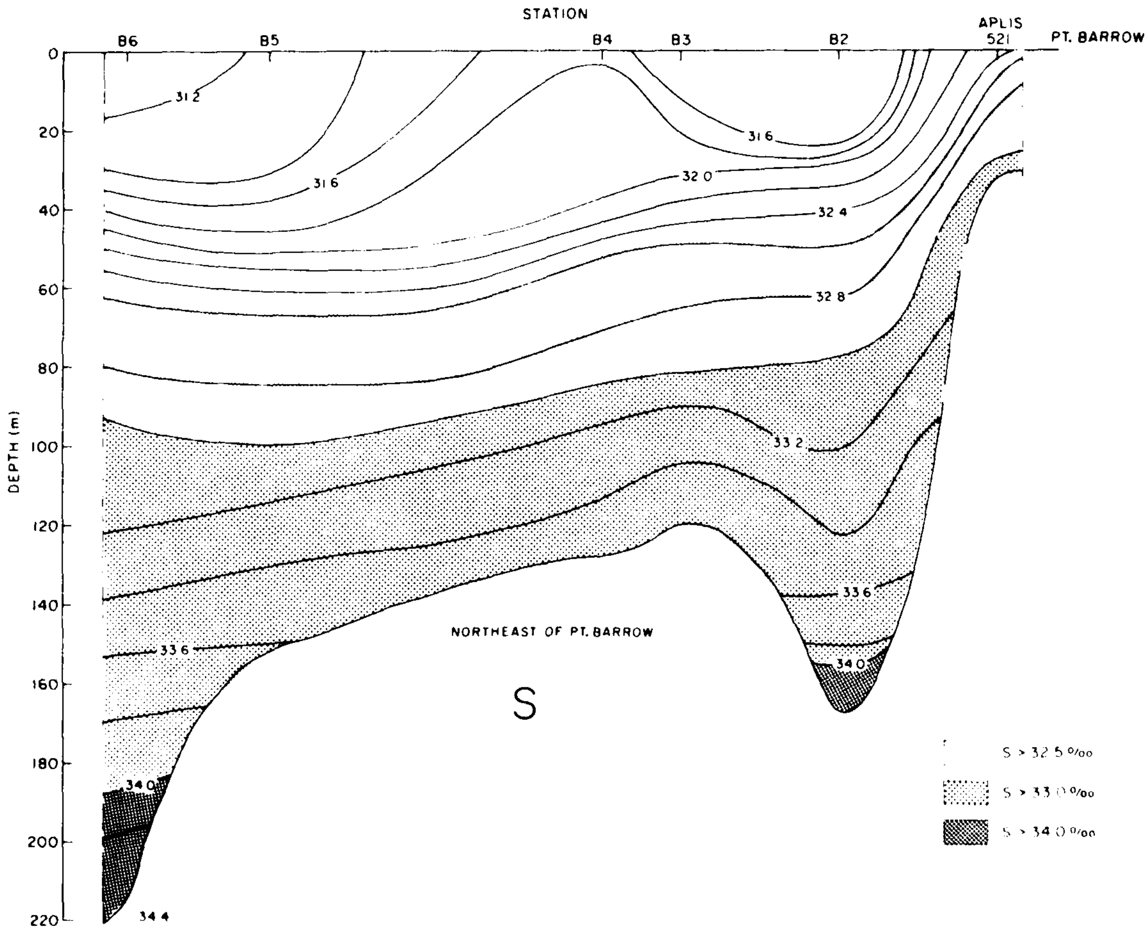


Figure 19b. Sections for Line B northeast from Pt. Barrow on 13-16 July 1977; also shown is station 521 from Ice Camp APLIS, which had just started its drift westward across the Chukchi Sea.

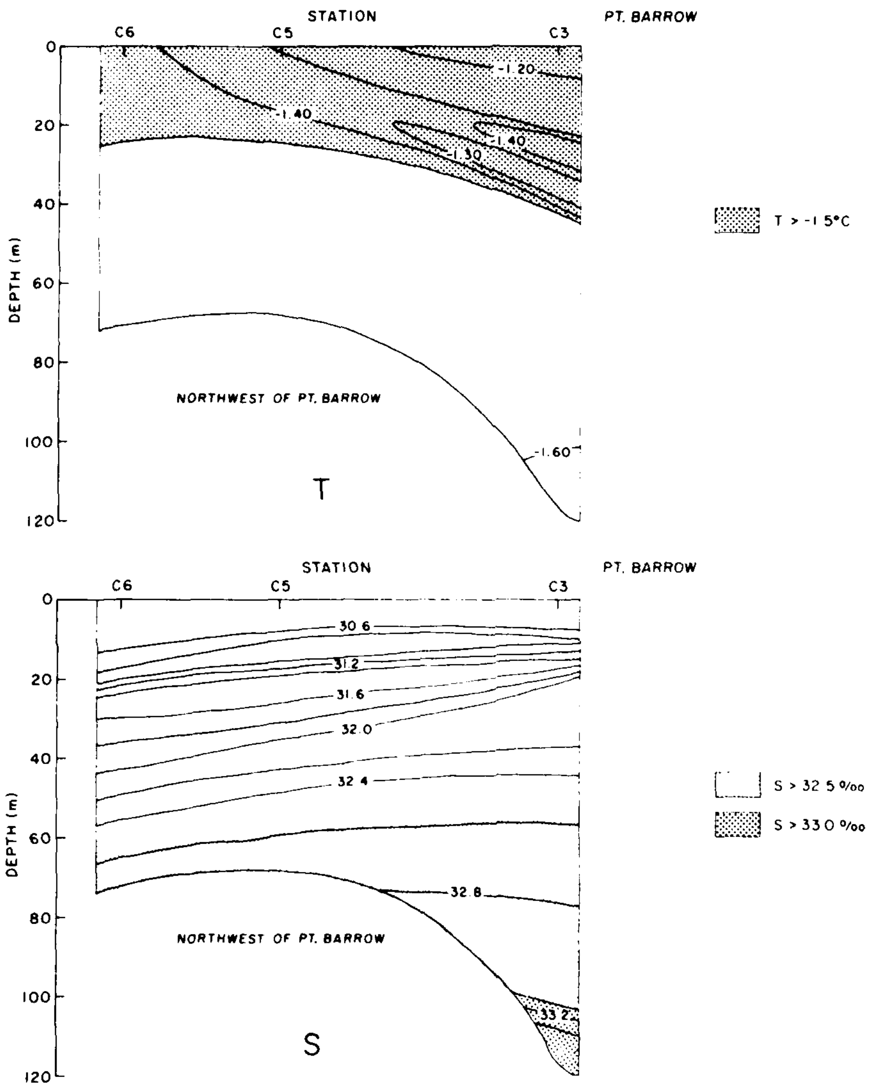


Figure 20. Sections for Line C northwest from Pt. Barrow on 17 July 1977.

The sections for Line C northwest of Pt. Barrow (Figure 20) also show warm (-1.2°C) water in the upper portion. In contrast to conditions during June (Figure 13), the isohalines are now nearly horizontal.

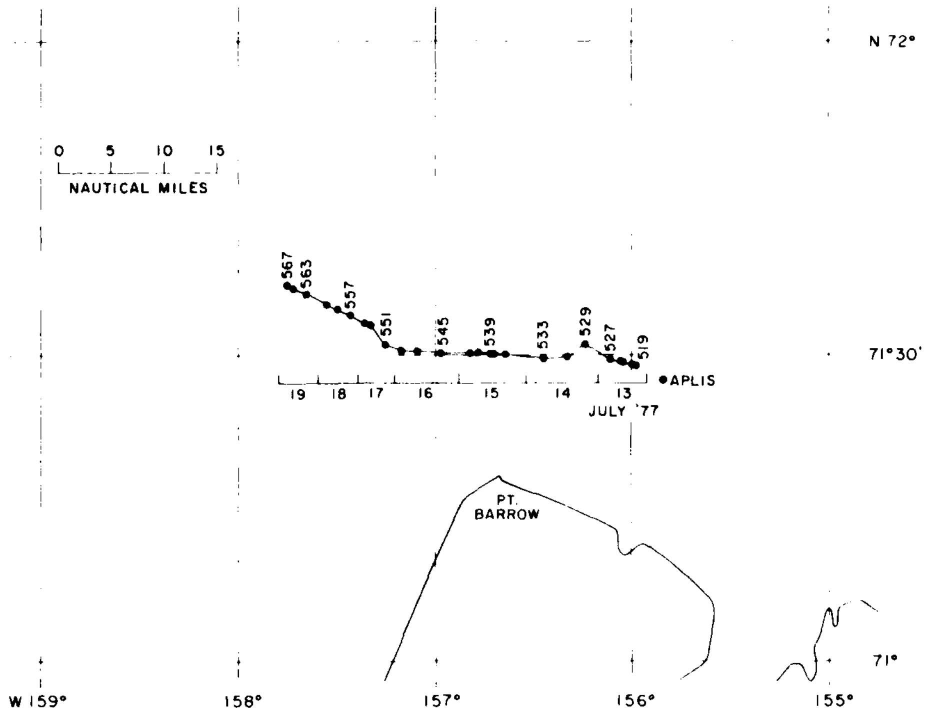


Figure 21. Drift of APLIS as determined by satellite fixes.

July CTD Profiles from Drifting Ice Camp

Although some movement of APLIS was detected on 9 July, not until 13 July did sufficient movement occur to cause an increase in water depth. From 13 to 19 July, the floe drifted westward across the Chukchi Sea. The path of the floe, as determined from satellite navigational fixes, is plotted in Figure 21. Much of the drift was along the Barrow Canyon where the depth was about 160 m.

During the drift, three CTD profiles were obtained each day (see Appendix E). The sections constructed from these profiles are shown in Figure 22. The lower regions contain several uniform layers with $T < -1.6°C$ and $S > 33.0‰$. These are believed to be formed by water masses that drained from the Chukchi Sea in several stages. A layer of uniform water ($S = 32.8‰$, $T < -1.6°C$) at 60 m is thought to be the remains of the winter-cooled water from the Chukchi Sea, now disturbed above by the warm coastal intrusion and below by the easterly movement of the more saline Chukchi drainage down the canyon.

At the east end of the section, both the isothermals and the isohalines rise into the shallows.

The warm intrusion appears to be spreading across the surface in a very irregular manner. The APLIS floe drifted along the edge of the pack with open water to the southwest. Some of the warming could have been at the surface; however, in many places a warm 20-m deep tongue is present, which is more indicative of an intrusion that is slightly heavier (more saline) than the surface waters which contain low-salinity melt water.

August Profiles from an Icebreaker

Paquette and Bourke[9] conducted an oceanographic cruise on the icebreaker BURTON ISLAND along the coast from Pt. Hope to Pt. Barrow from 26 July to 5 August 1977. A map of the stations taken during the cruise is shown in Figure 23. Temperature and salinity profiles taken by APL are presented in Appendix D for the stations shown on the figure.

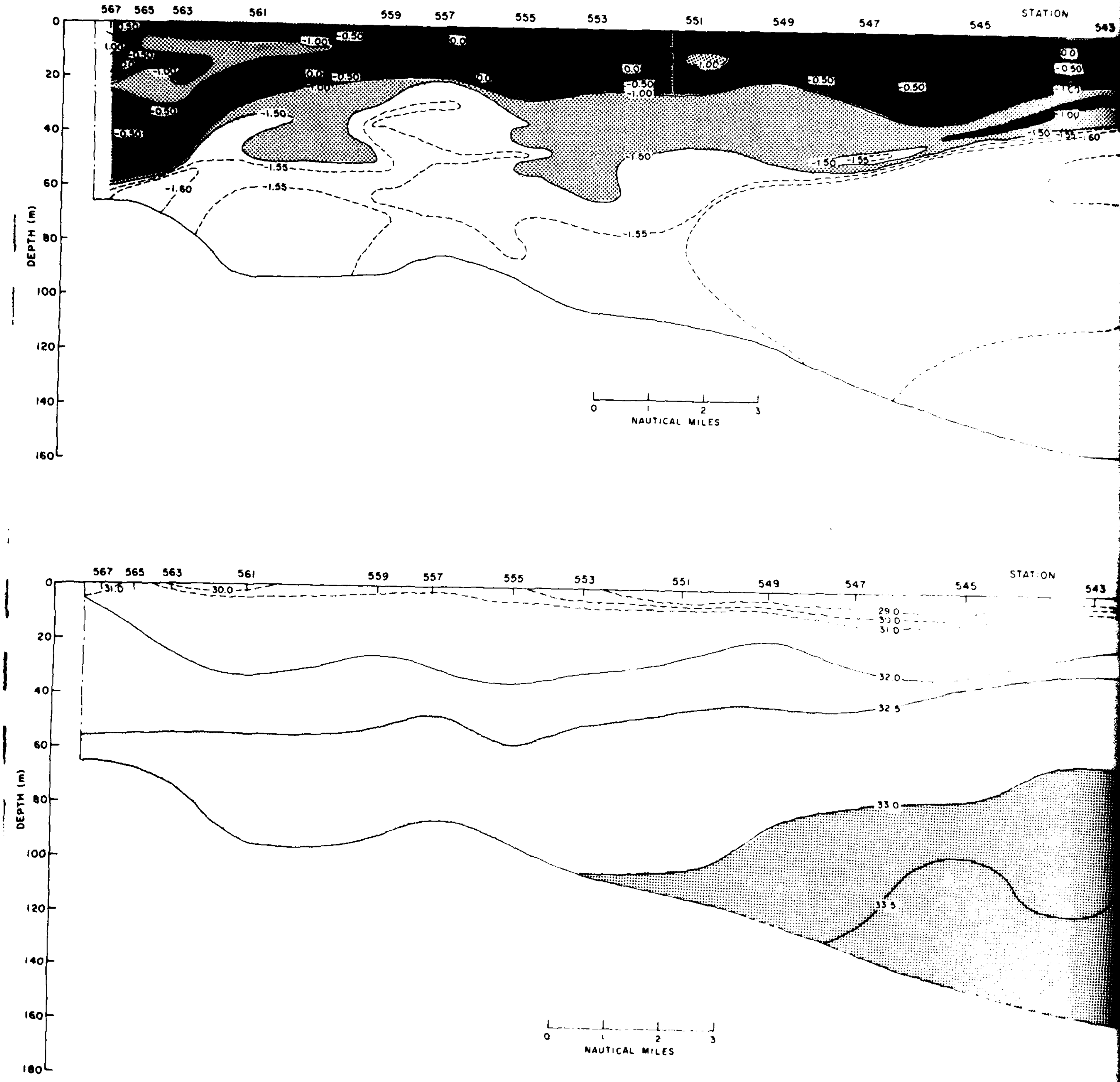
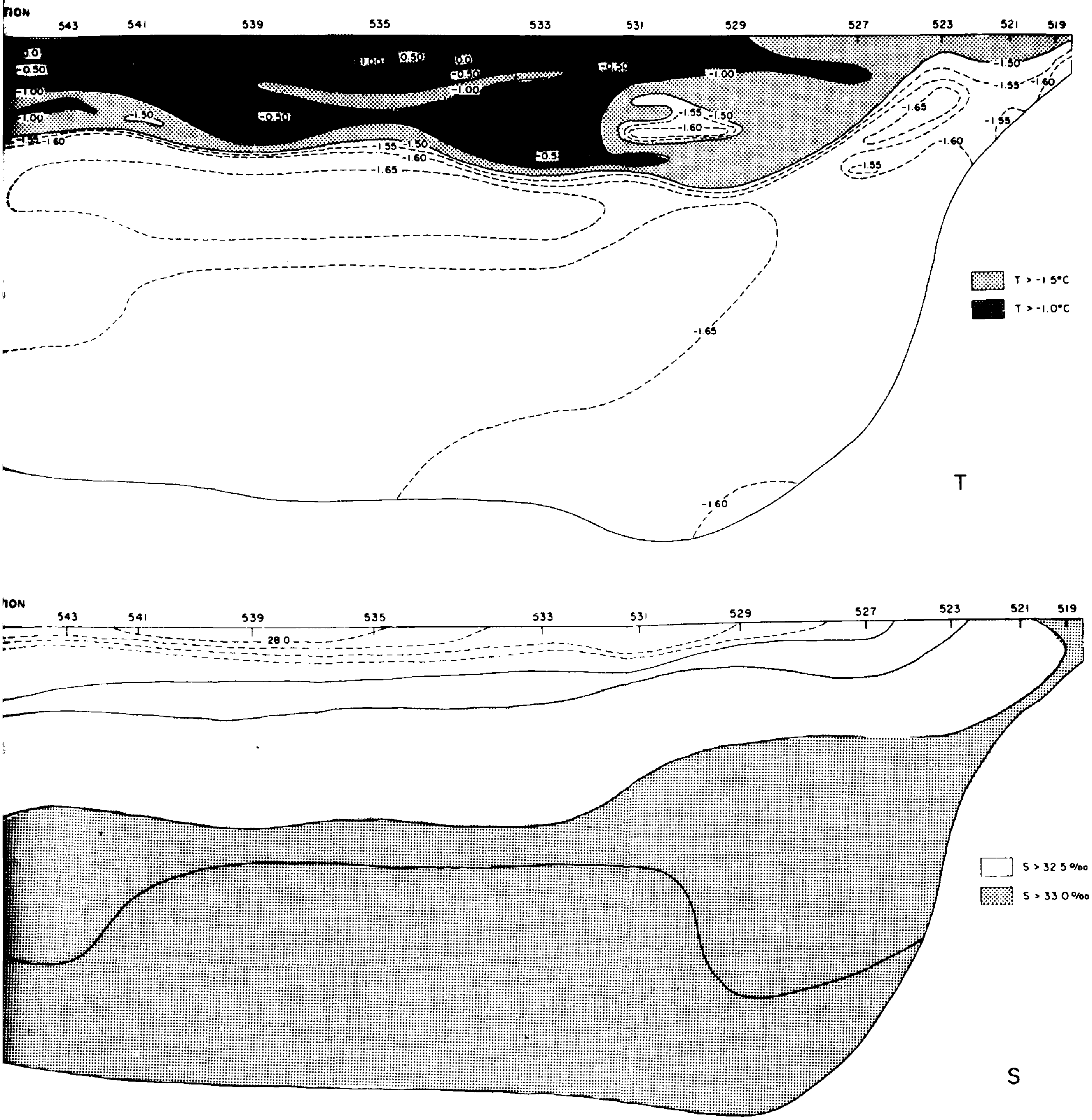


Figure 22. Sections for the drift of APLIS across the Barrow Ca



Barrow Canyon, 13-19 July 1977.

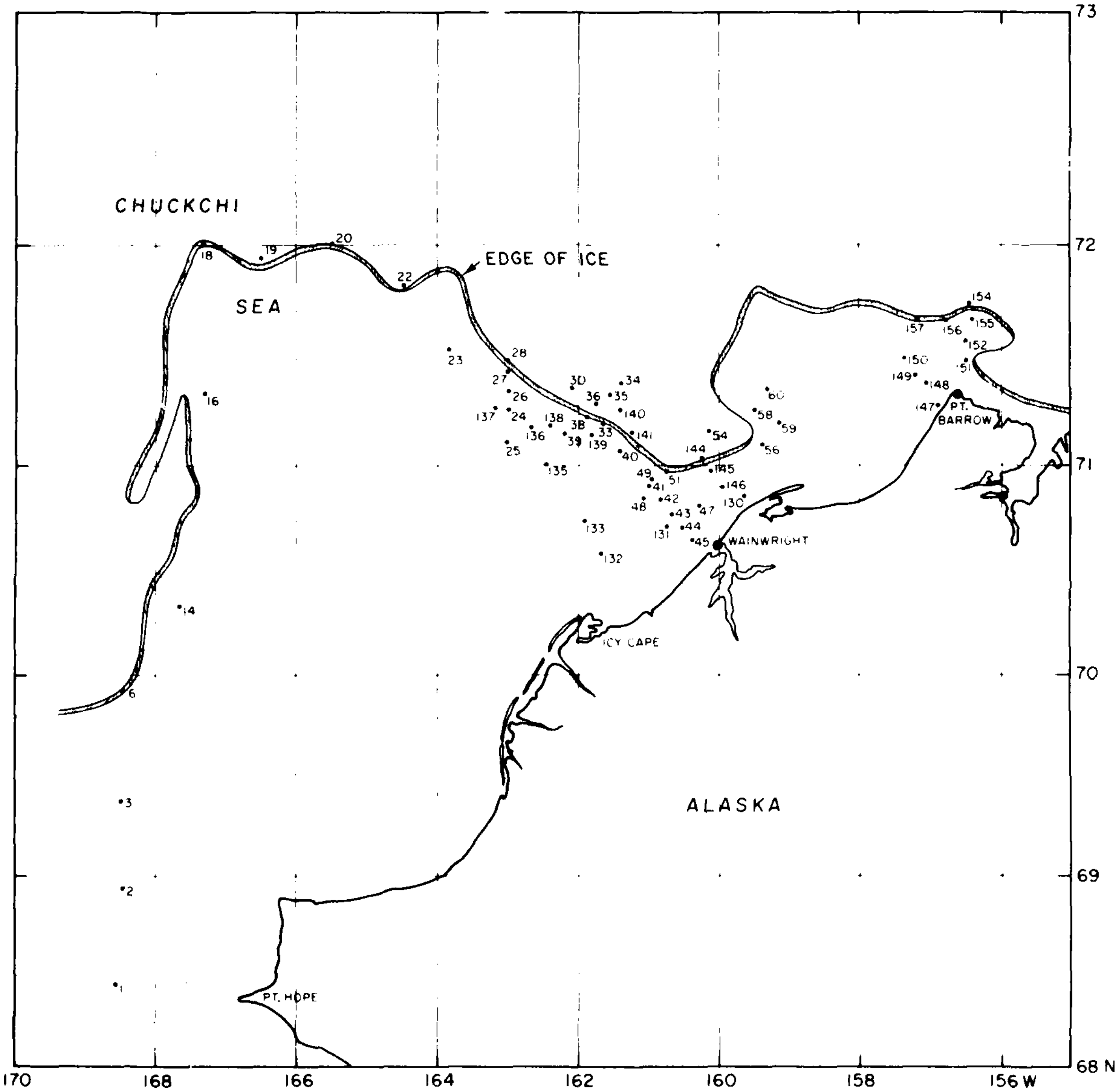


Figure 23. Location of stations taken by Paquette and Bourke[9] during the cruise of the icebreaker BURTON ISLAND, 26 July to 5 August.

A line of stations was taken on 5 August that extended northward from Pt. Barrow about 25 n.mi. (46 km) as shown in Figure 24. Sections along this line have been plotted in Figure 25 for comparison with our July measurements in the same area. The warm intrusion from Bering Strait appears to extend to the bottom at Station 151 (140 m depth). Below 30 m depth at Station 152, the cold, more saline drainage from the Chukchi Sea still remains. Once again, the water flowing northeastward along the coast clings closely to the shore. In the spring this water was more dense than the existing water; now in late summer it is lighter and the isohalines slope downward toward the shore.

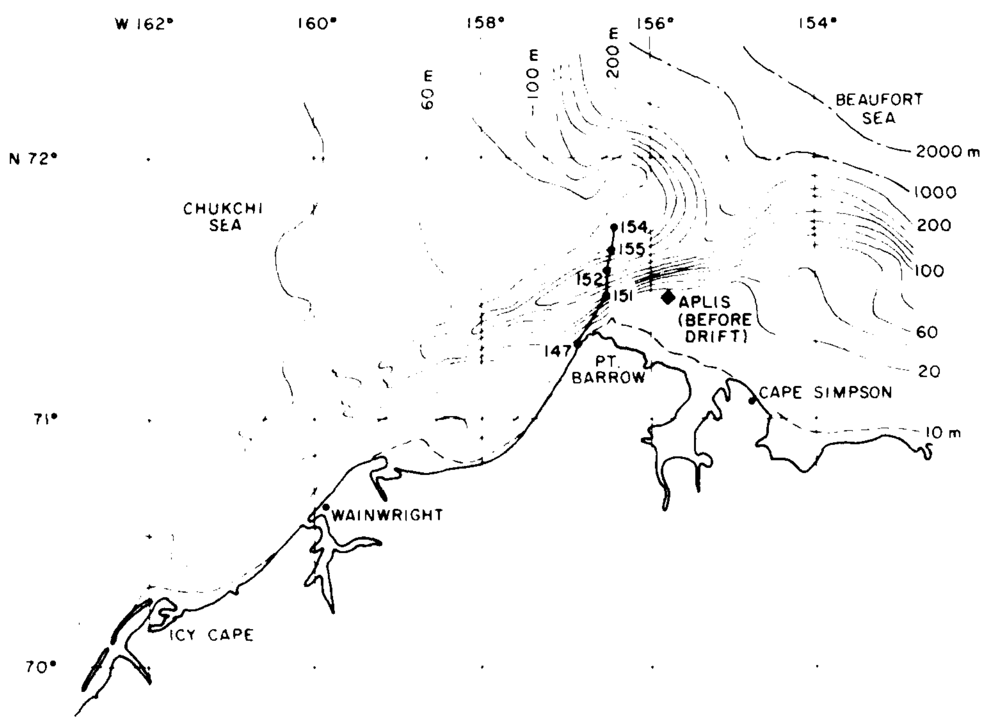


Figure 24. Location of five stations on a line northward from Pt. Barrow on 5 August during the cruise of the icebreaker BURTON ISLAND.

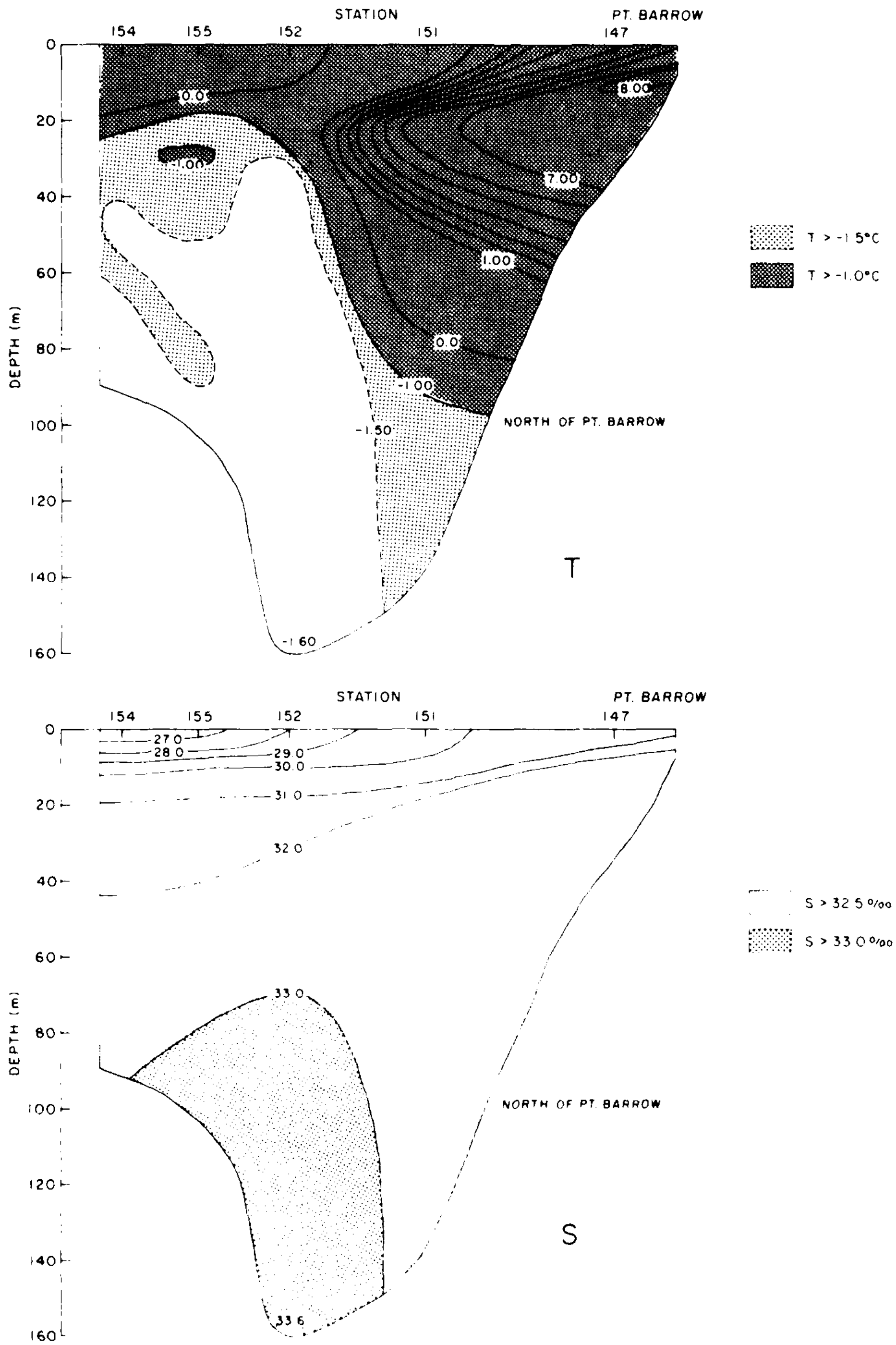


Figure 25. Sections for the line northward from Pt. Barrow on 5 August 1977 (from the BURTON ISLAND).

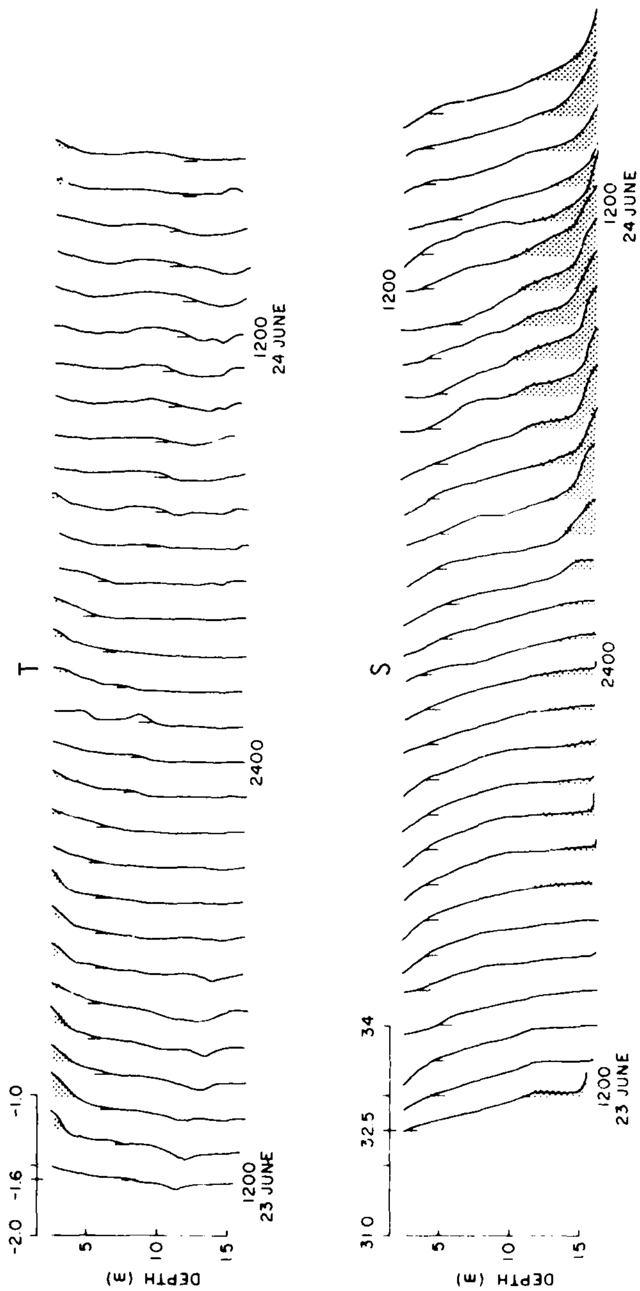


Figure 26. Time series of temperature and salinity profiles at APLIS on 23 and 24 June 1977.

Time Series at Stationary Ice Camp

At two periods during the ice camp occupancy, when temperature and salinity conditions seemed highly variable, CTD profiles were measured every hour.

On 23 June, the temperature near the surface began increasing while the salinity at depth was decreasing. Starting at noon on 23 June, a 30-h CTD time series was obtained with a cast each hour. The results are plotted in Figure 26. The vertical ticks on the profiles indicate -1.6°C and 32.5‰; the shading indicates salinity greater than 33.0‰. An increase in salinity at the bottom is accompanied by a slight increase in temperature.

During this period, current measurements were taken every 4 h. The direction appeared to rotate, with a period of about 26 h (see Figure 27 and further discussion under Current Measurements at Ice Camp APLIS). During the increases in salinity, the current was toward the south.

A second hourly CTD time series was started at 0800 on 4 July and ran for 40 h. The results are shown in Figure 28. During this period, the salinity at the bottom of the water column passed through a minimum, as did the temperature in the lower half.

CTD Profiles at Stationary Ice Camp

CTD profiles were taken at the stationary APLIS camp three or four times each day from May through July. The water depth was only 15 m, and, with the ice keels projecting 2-5 m downward, the water movement through the area must have been greatly disturbed.

Data were recorded during both the descent and the ascent of the probe from the CTD profiler (the profiler was fastened to the wall over a hole in the generator hut). Comparison of the two records reveals that the data recorded during the descent contained errors caused by two factors. First, the probe was stored in the warm hut and was not placed in the water long enough to reach a thermal equilibrium before lowering; therefore, the water passing through the cell was warmed, increasing its conductivity. The second error was due to a layer of very-low-salinity melt water in the hole. This water did not flush out of the probe immediately and often decreased the conductivity during the lowering. The lowering and the stop at the bottom to read the dials appear to have provided sufficient time for the probe to reach a temperature equilibrium and complete flushing, so that the ascent was free of these errors. However, the data taken during the ascent are degraded by the turbulence created by the cylindrical housing above the probes.

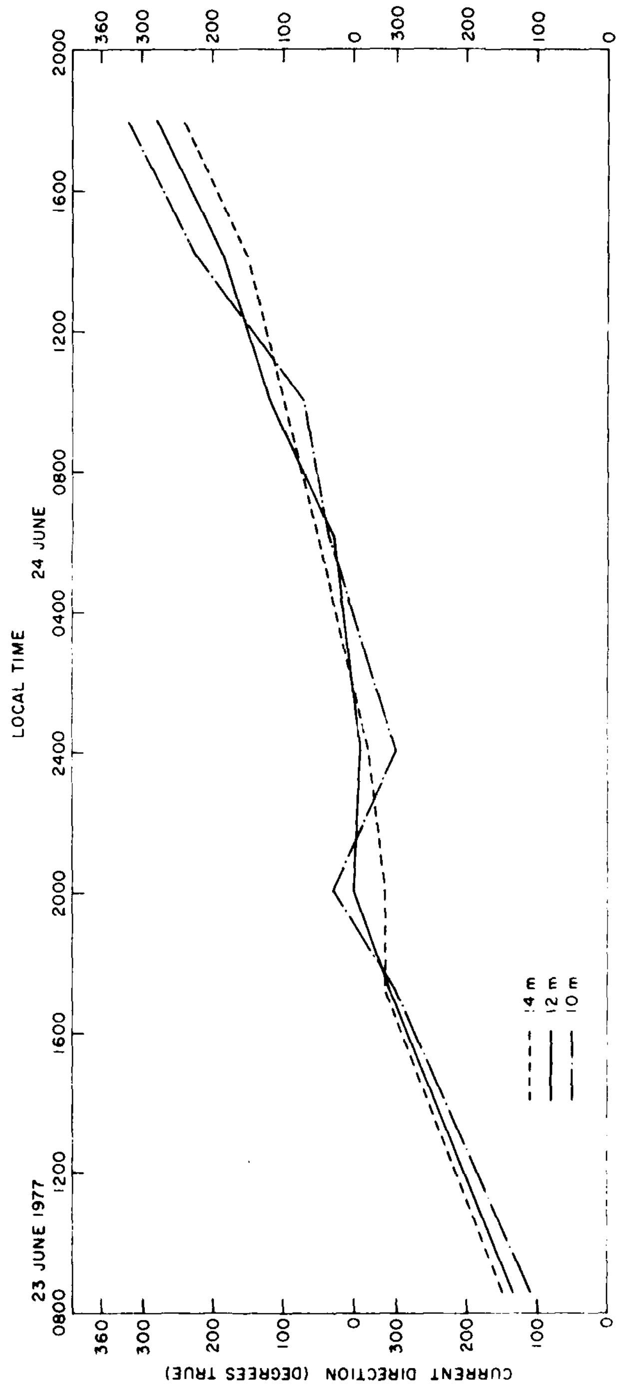


Figure 27. Variations in current direction at APLIS, 23 and 24 June 1977.

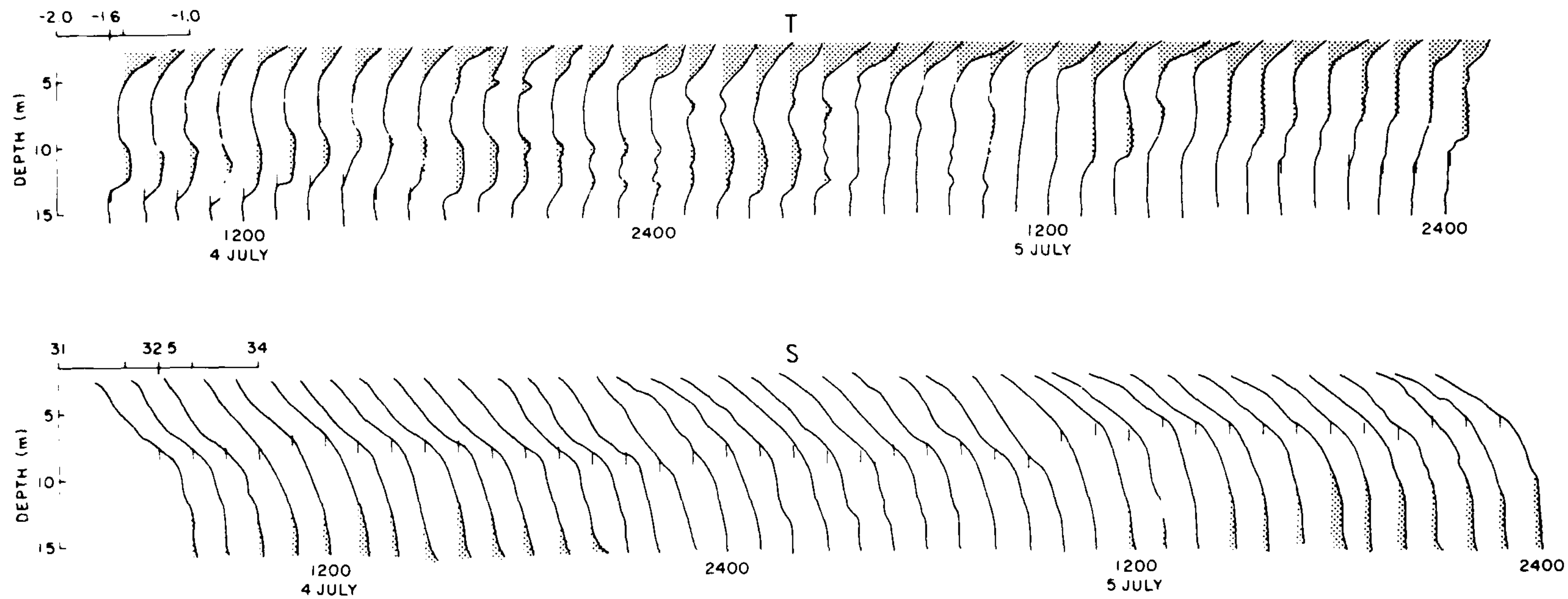


Figure 28. Time series of temperature and salinity profiles at APLIS on 4 and 5 July 1977 (shading indicates T > -1.5°C and S > 33‰).

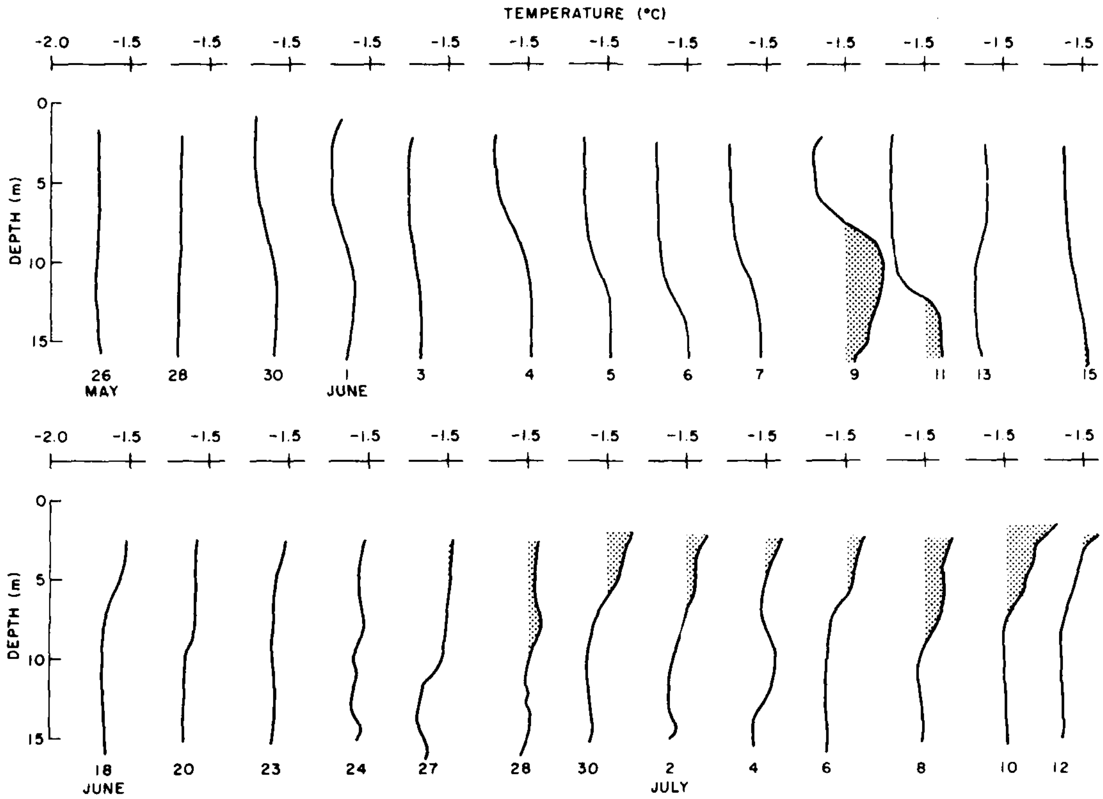


Figure 29. A summary of the temperature profiles at APLIS.

Selected profiles are plotted in Figures 29 and 30 to show the trend during the occupancy. Shading has been applied to emphasize temperatures above -1.5°C and salinities above 33.0‰. Water with these properties must be either Atlantic water that has surged up slope or accumulated Chukchi drainage that has moved up the slope and been warmed by the sun in the open water to the north of the camp.

The trends of the temperature and salinity variations are easier to follow in Figure 31 in which the temperature and salinity at depths of 6 and 14 m have been plotted for the 50-day period. Some of the changes are rather large and abrupt. The sudden increase to -1.5°C and 33.0‰ at 14 m on 4 June is in agreement with the profiles taken along the edge of the shore-fast ice (Figure 14). The sudden increase in temperature to -1.2°C on 9 June, with the salinity also increasing, is in agreement with the high temperature observed at station E5 on that date. The sudden decrease in temperature at 14 m on 13 June is in agreement with the low temperatures observed off the ice edge on 13 June (Figure 16), as is the fact that the salinity at the ice camp remained high.

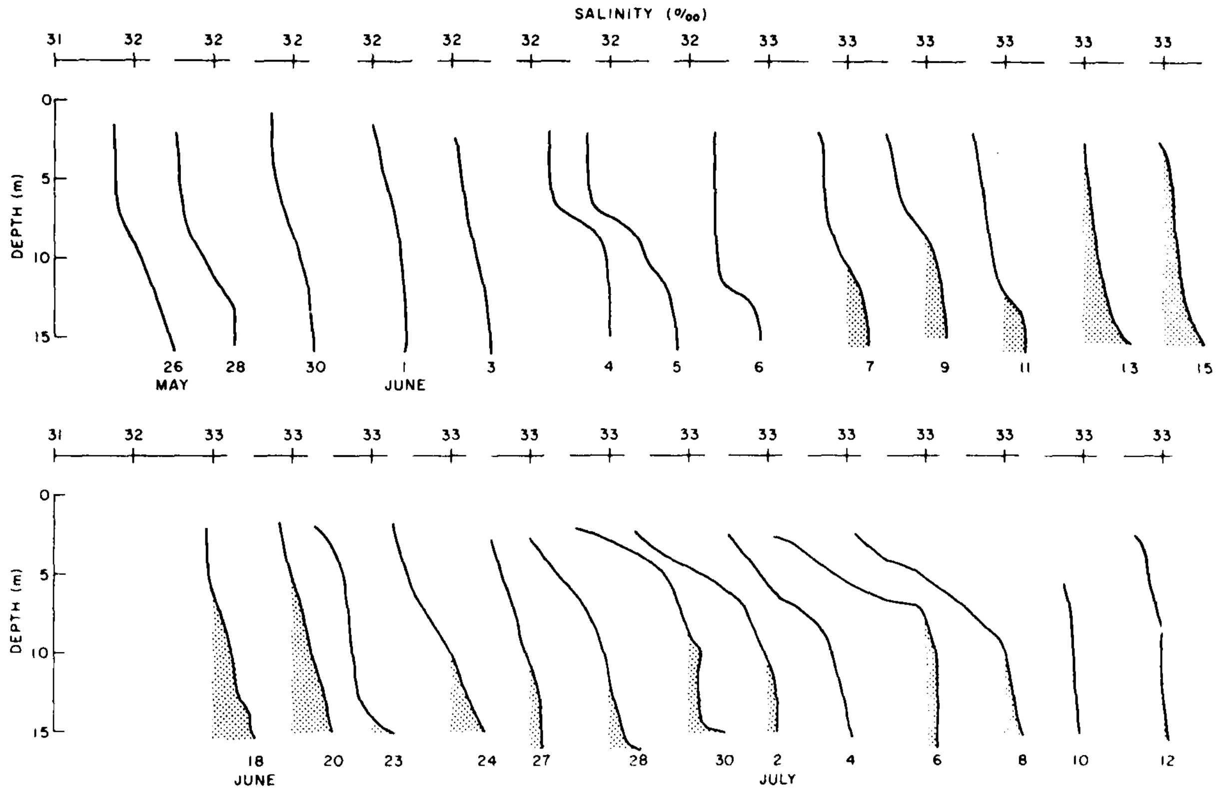


Figure 30. A summary of the salinity profiles at APLIS.

Weather Recording at Ice Camp

Weather conditions were recorded at APLIS several times each day. A barometer (from the Naval Arctic Research Laboratory) recorded data continuously. The wind speed, wind direction, and air temperature from an anemometer and electric thermometer on the top of a 7-m high staff were read and recorded by hand. A glass/mercury thermometer, enclosed in a standard louvered box 1 m above the ice surface, was also read and noted.

The wind instrument had a compass mounted on the same structure so that any rotation of the mast because of loose stays or rotation of the floe would be corrected for. The compass was very sluggish but in most cases had plenty of time to respond.

On warm days the temperature on top of the staff was considerably higher than in the box 1 m above the ice. This caused noticeable differences in sound transmission and reverberation in the air; e.g., when listening to a distant helicopter and when rifles were fired to scare off the polar bears.

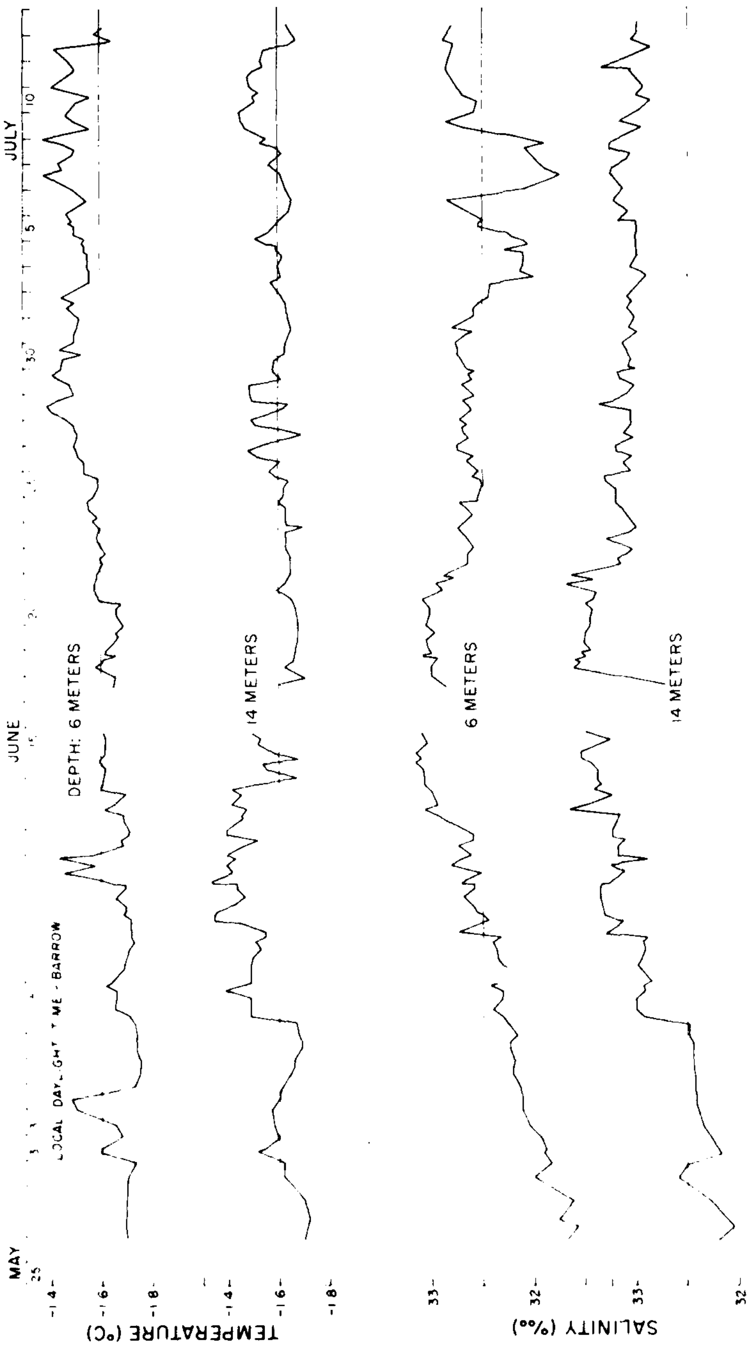


Figure 31. Temperature and salinity at two depths during the period in which the APLIS floe was shore fast.

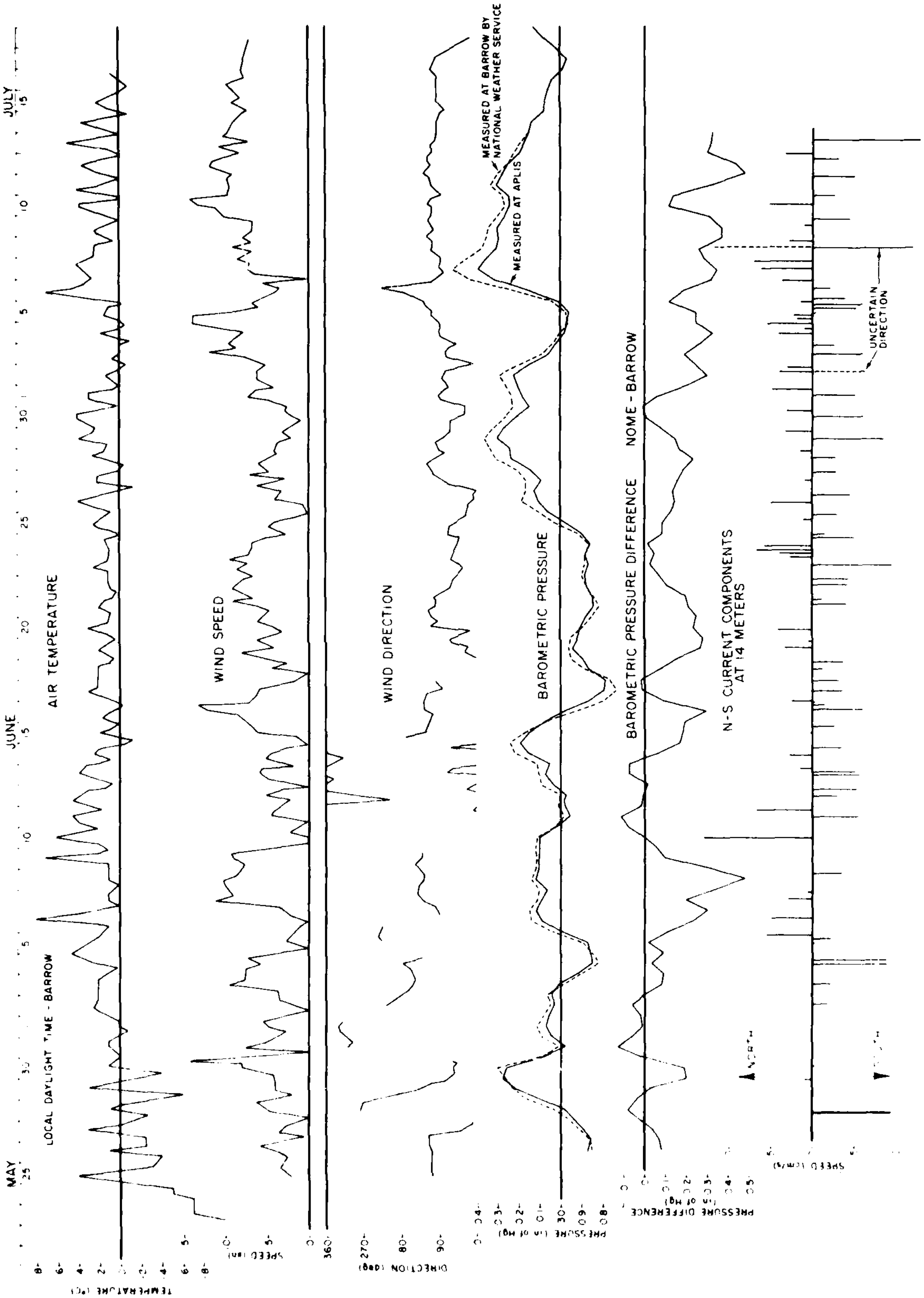


Figure 32. Weather and current summary at APLIS.

Figure 32 is a time plot of these observations along with the currents and barometric pressure, which were measured routinely throughout the 2-month period. The air pressure data obtained by the National Weather Service at Nome and Barrow were used to prepare a record of the air pressure at Barrow and the difference between Barrow and Nome for comparison with the APLIS record. These data have also been included in Figure 32.

Figures 31 and 32 do not reveal any high correlations between the various measurements. The sudden increase in temperature and salinity on 4 June is accompanied by a decrease in air pressure, but there are many other air pressure changes that are not accompanied by temperature and salinity changes.

Current Measurements at Ice Camp APLIS

A Marsh-McBirney electromagnetic current meter, combined with a fluxgate compass, was attached to 100 m of cable and used to measure the currents at APLIS. The probe was lowered and stopped at selected depths. After the meter stabilized, the x and y components of the current and of the magnetic direction of the housing were read manually and the values written in a notebook. The measurements were usually repeated at the same depths on the way up. The "down" and "up" measurements often agree very well, but large disagreements were not uncommon. Because the data were read and recorded manually, errors could easily occur, especially in the sign of the x and y components.

During the time that APLIS was stationary, current measurements were taken about twice each day from 28 May to 13 July. There were also two time studies in which currents were measured at 4-h intervals. Figure 33 shows the current's magnitude (absolute) and direction (true) vs time at six depths during that period. These measurements are also presented in more detail in Appendix F using a polar diagram at each depth to show magnitude and direction and the repeated measurement as the instrument was raised.

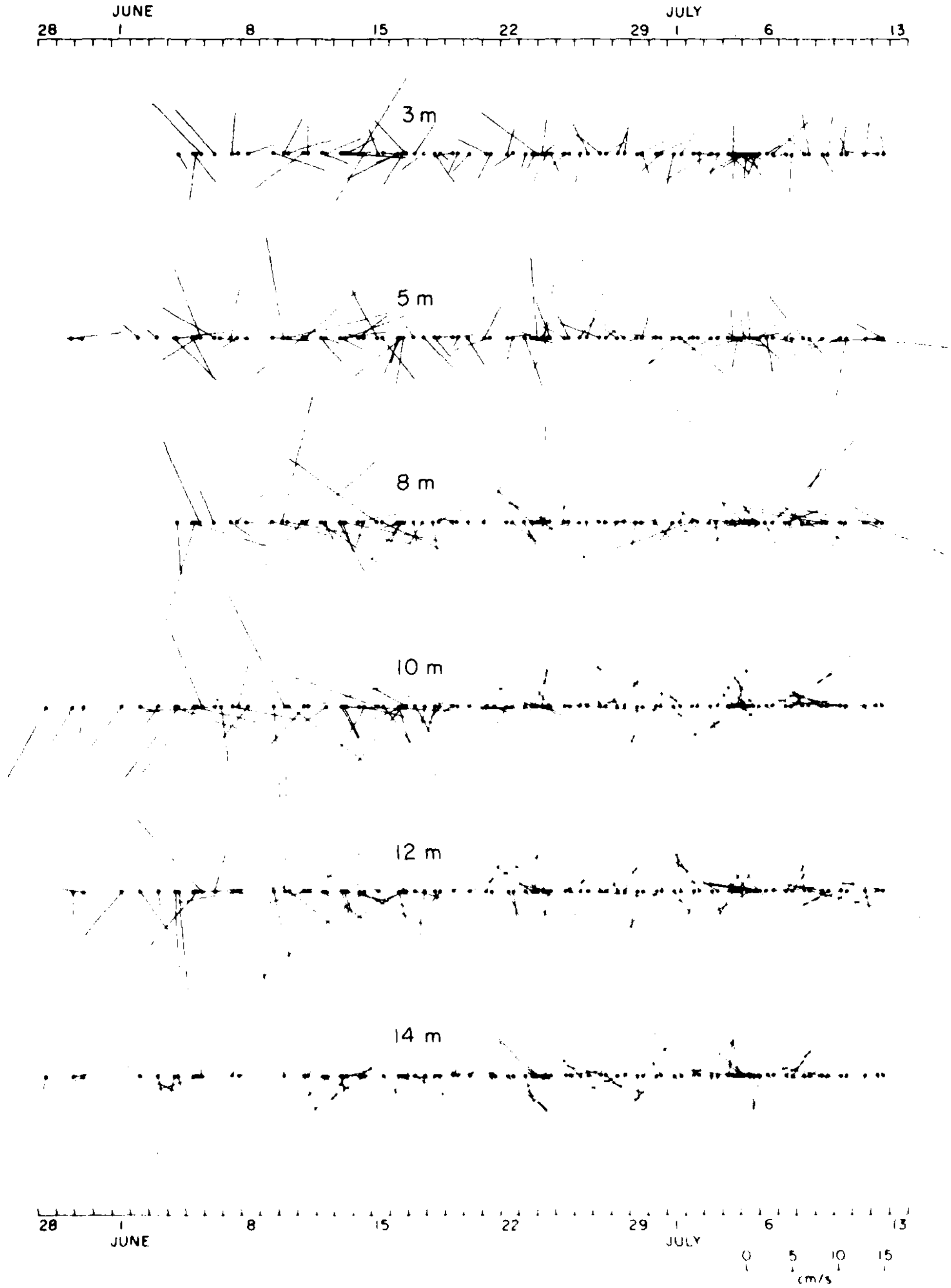


Figure 33. Current direction and magnitude at six depths at stationary APLIS.

The north-south component of the current at 14 m has been plotted for comparison with other variables in Figure 32.

During the time series on 23 and 24 June, the current appeared to rotate. A plot of the current direction during this time was shown in Figure 27 for depths of 10, 12, and 14 m. When the up and down measurements were greatly different, an average was plotted. A least-squares fit of these points to a straight line gives a rotation of 301°/day and 294°/day, respectively, for the 12 and 14 m depths during the 3-day period. (The standard deviation of the current direction from these lines is 35°.) This seems to indicate some kind of eddy motion such as that detected in the deeper areas of the Arctic[10] in 1972. In that study, a clockwise rotation of 318°/day was observed (Event No. 2); this is in very close agreement with our findings and indicates the possibility that we were also observing some effects of baroclinic eddies.

Figures 34-38 are plots of the currents measured after APLIS began to drift westward. These measurements are all relative to the floe. If the drift rate and track were accurately known, we could determine the absolute currents; however the jitter in the position data is so large that only the average drift over 1 or 2 days is obtainable. In most of the plots, the relocation of the origin necessary to correct for the drift velocity has been indicated. The vectors, however, have not been drawn because the drift is so inaccurately known.

Water-Sample Analysis for Salinity and Oxygen

Water samples were occasionally taken at the ice camp and at the helicopter stations. All oxygen samples were treated immediately to fix the oxygen content. These samples were returned to Seattle for analysis at APL. Some of the salinity samples were analyzed at the ice camp; others were returned to the University of Washington for analysis in the Oceanography Department's laboratory. The results, listed in Table II, were used to check the calibration of the conductivity cell of the CTD unit. As shown in the table, the analyses agreed with 0.13‰.

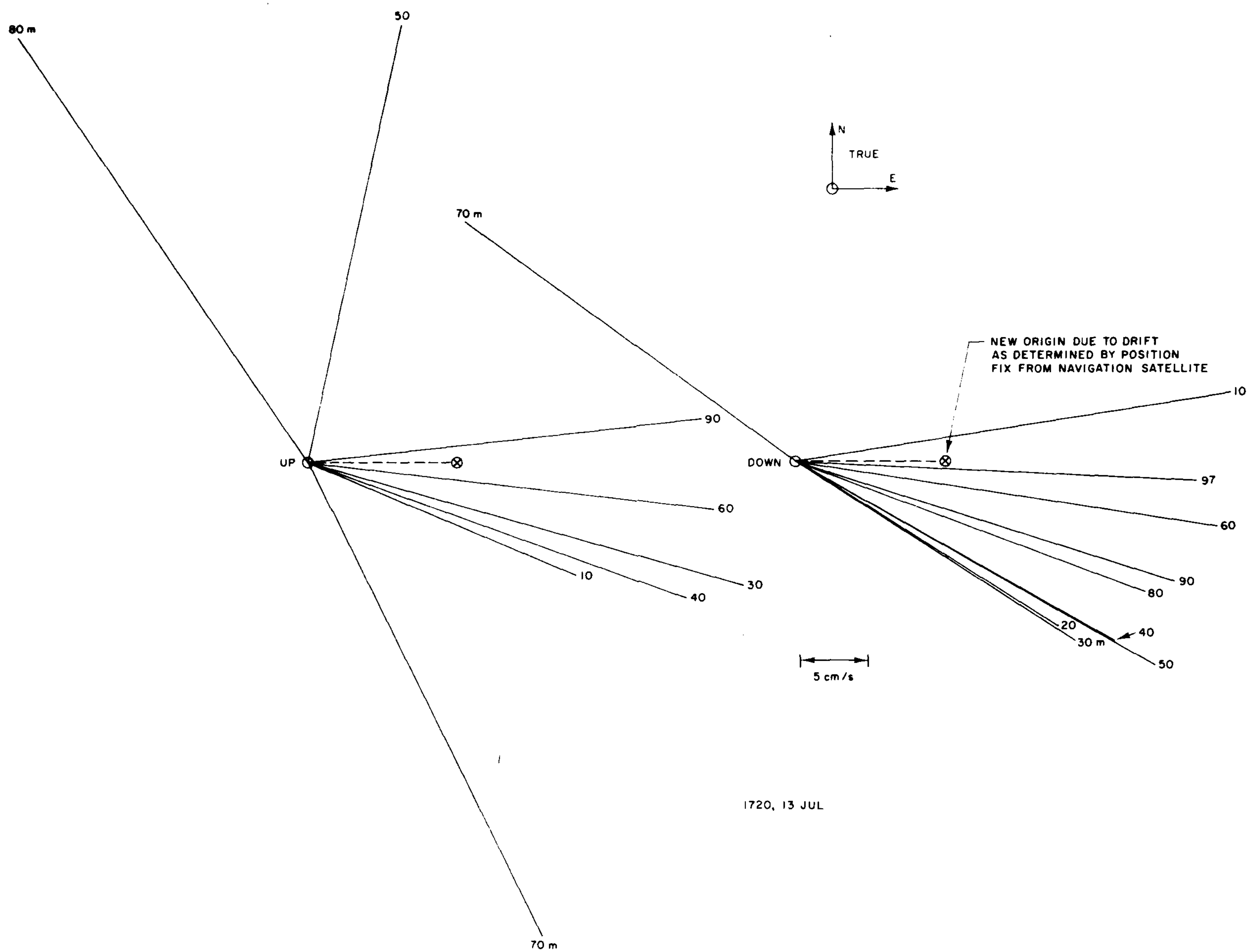


Figure 34. Current measurements at APLIS during the drift westward. The lines represent current vectors from the circle outward.

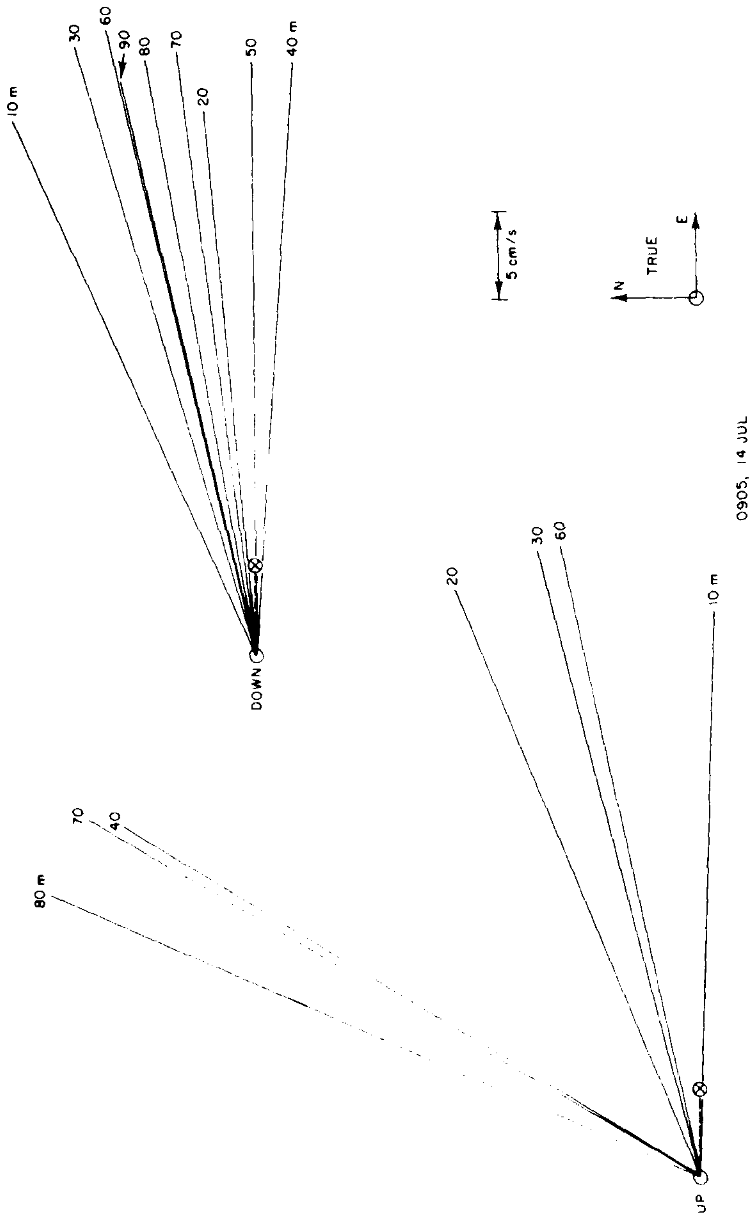


Figure 35. Current measurements at APLIS during the drift westward.

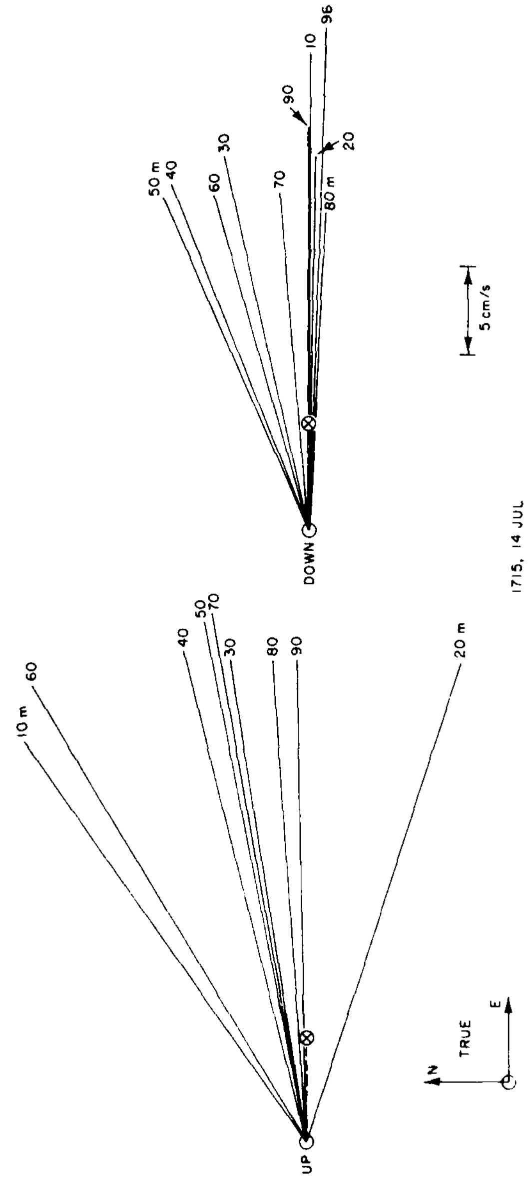


Figure 36. Current measurements at APLIS during the drift westward.

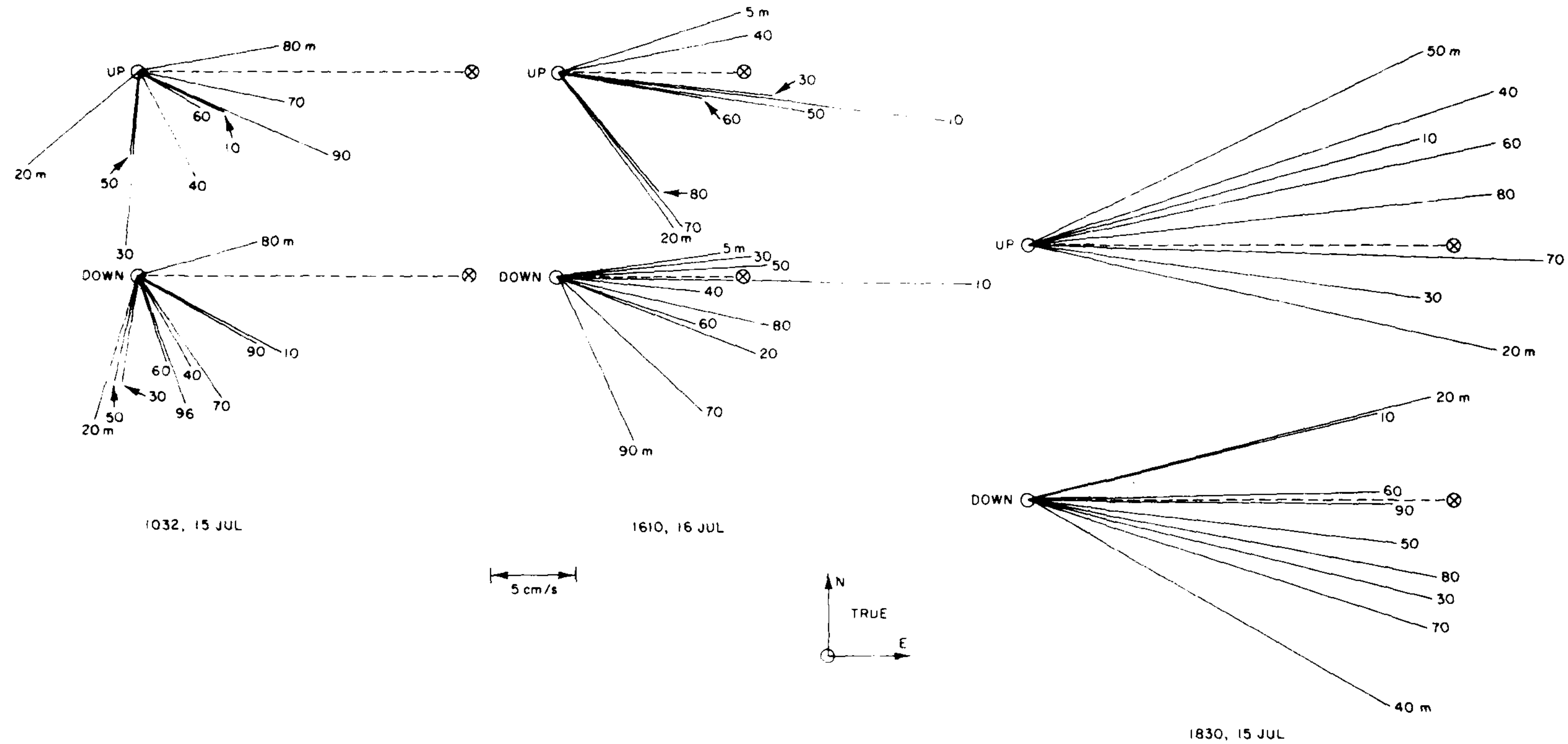


Figure 37. Current measurements at APLIS during the drift westward.

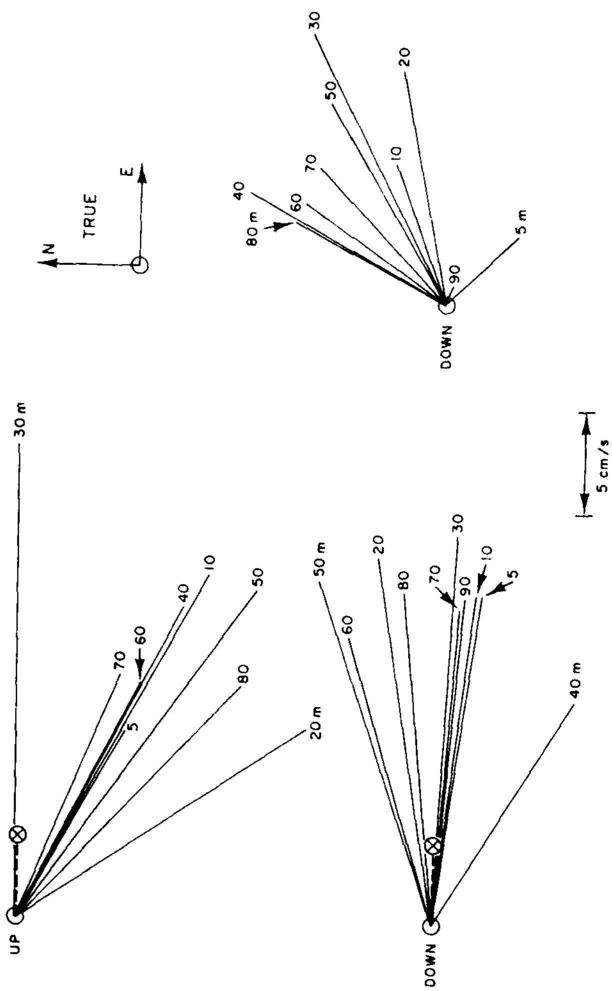


Figure 38. Current measurements at APLIS during the drift westward.

Table II. Water samples analyzed for salinity.

Sample Number	Date	Local Time	Depth (m)	Location	Salinity Analysis at U.W. (‰)	Salinity Analysis at APLIS (‰)	Difference (‰)
51	May 28	1000	5	APLIS	31.58	31.54	0.04
52	28	↑ to	9	APLIS	31.77	31.64	0.13
53	28	↓	13	APLIS	32.28	32.15	0.13
54	28	1200	13	APLIS	32.29	32.25	0.04
59	June 4	1730	5	APLIS	32.30	---	---
60	4	1730	15	APLIS	33.04	32.96	0.08
XX	9	0800	14	APLIS	33.41		
55	10	1530	23	STATION E6	32.04		
56	10	1530	53	STATION E6	32.77		
57	10	1530	220	STATION E6	34.01		
162	24	1200	13.5	APLIS	33.08 *		
152	24	1200	13.5	APLIS	33.04 *		
112	27	0900	13.0	APLIS	33.18		
116	27	1643	111	STATION E12	32.95		
114	27	1714	160	STATION E12	33.84		
113A	July 16	1540	154	STATION B6	33.73		
112A	July 16	1540	210	STATION B6	34.52		

*Duplicate analysis of two samples from the same sampling bottle.

The results of the dissolved oxygen analysis are listed in Table III. Figure 39 is a plot of dissolved oxygen content versus depth. Note the disparity in the values for samples taken from the same sampling bottle, which are indicated by a connecting line. The averages of the values in Figure 39 are plotted in Figure 40 where the abscissa is now the percent of saturation and the temperature and salinity of the sample have been added.

For the deeper measurements, duplicate oxygen samples are in fair agreement. In some instances at the camp, however, three samples taken from the same sampling bottle gave widely varying results. This may have resulted from the warm temperature of the generator hut in which the samples were treated. With too much warming before treatment, some oxygen could have been lost. We did not record the sampling order and thus can not verify this explanation.

Table III. Water samples analyzed for oxygen content.

Sample Number	Date	Time	Depth (m)	Location	Oxygen Content (mℓ/liter)
51	May 28	1000	5	APLIS	8.02
52	28	↑ to	9	APLIS	7.88
53	28	↓	13	APLIS	4.64
54	28	1200	13	APLIS	7.51
59	June 4	1730	5	APLIS	7.90
60	4	1730	15	APLIS	7.25
55	10	1530	23	Station E6	7.34
56	10	1530	53	Station E6	6.79
57	10	1530	220	Station E6	6.01 *
58	10	1530	220	Station E6	5.71
162	24	1200	13.5	APLIS	5.35 *
152	24	1200	13.5	APLIS	6.54
112	27	0900	13	APLIS	7.38 *
113	27	0900	13	APLIS	7.58
116	27	1643	111	Station E12	7.47 *
117	27	1643	111	Station E12	6.48
114	27	1714	160	Station E12	6.75 *
115	27	1714	160	Station E12	6.67
100	July 10	1215	14	APLIS	7.99 *
101	10	1215	14	APLIS	6.97
102	10	1215	14	APLIS	6.28
103	13	1215	31	APLIS Drifting	4.04 *
104	13	1215	31	APLIS Drifting	3.65
105	13	1215	31	APLIS Drifting	4.81
113A	16	1540	154	Station B6	7.00 *
152A	16	1540	154	Station B6	6.99
112A	16	1540	210	Station B6	5.94 *
115A	16	1540	210	Station B6	5.86

*Duplicate analysis of samples from the same sampling bottle

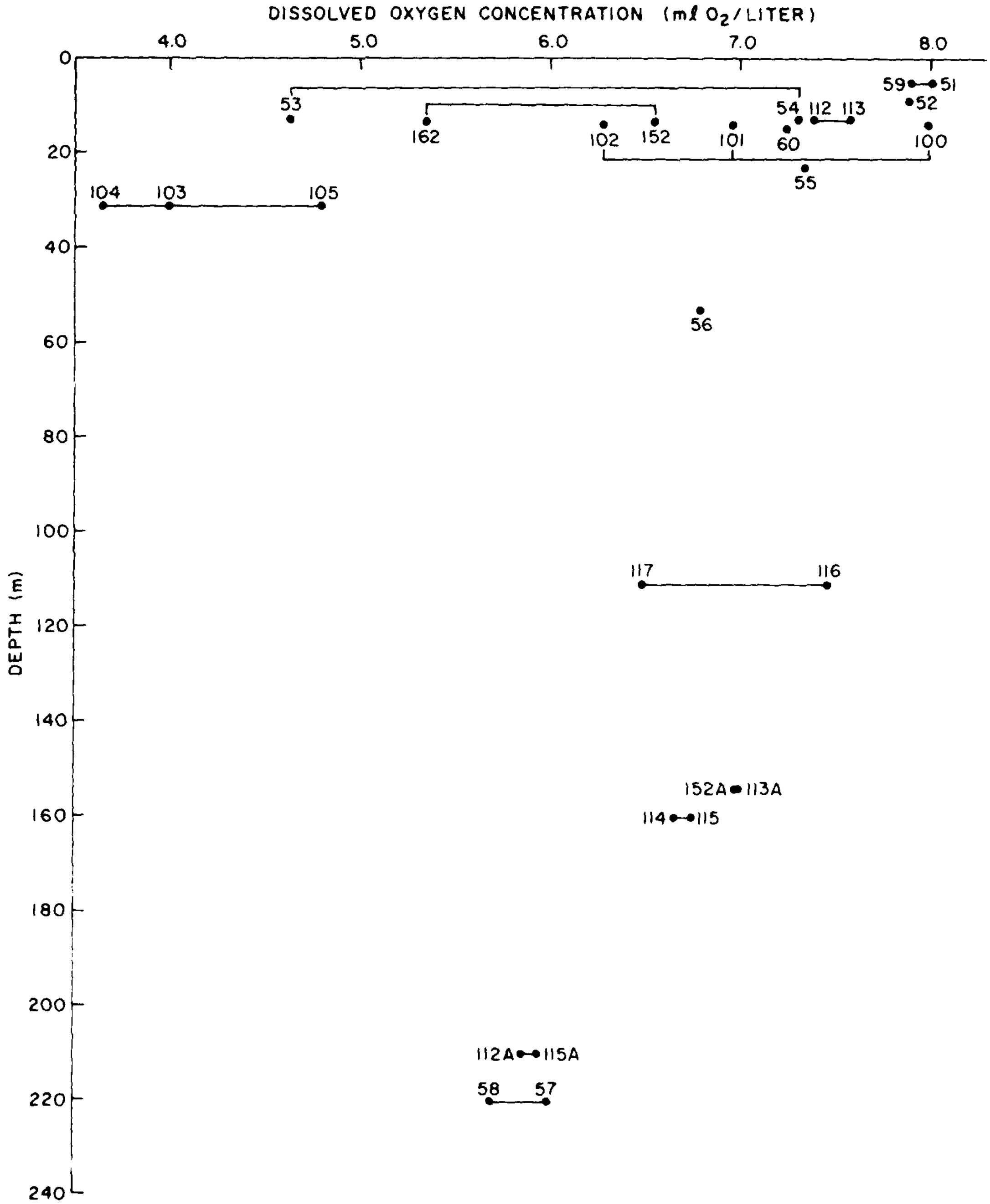


Figure 39. Oxygen concentration for all samples. The connected points indicate several samples that were analyzed from the same sampling bottles.

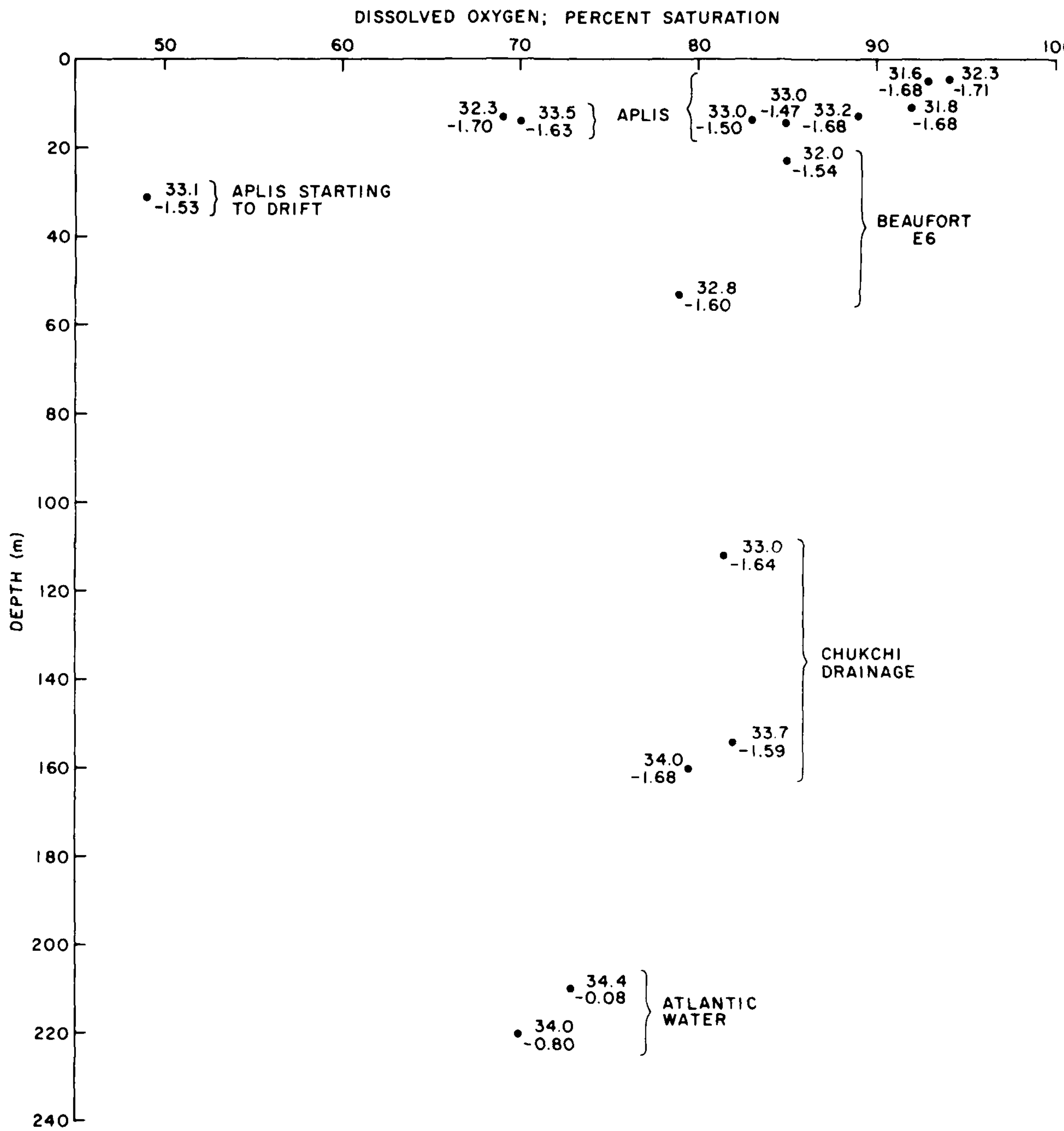


Figure 40. Oxygen content in percent of saturation. Averages of the values shown in Figure 39 are plotted with the salinity and temperature shown alongside.

The Atlantic water, which was obtained below 200 m, definitely has a low oxygen content (about 70% of saturation). The cold drainage from the Chukchi Sea has a higher oxygen content (about 81% of saturation) which is, however, about the same as that at depths of 23 and 53 m at station E6 beyond the canyon mouth (see Figure 15). This is evidence that the cold, deep water that we have labeled Chukchi drainage water did, indeed, come recently from the lower depths of the shallower Chukchi Sea.

The more consistent samples taken when APLIS was on the shallow shelf have a salinity near 32‰ and an appreciably higher oxygen content, more like surface water. Other samples show a low oxygen content like that of Atlantic water; the salinity of these samples is high enough to indicate Atlantic water, but the low temperature indicates that this water is drainage from the Chukchi Sea. Some of the low oxygen values are considered unreliable, however, because of the large spread in the results for two samples from the same depth.

Satellite Photographs and Infrared Images

Photographs and infrared images of the eastern Chukchi Sea were taken daily by the NOAA satellite. Copies of these pictures were prepared by the National Environmental Satellite Service at the Gilmore Creek Observatory near Fairbanks and delivered to us weekly. These prints were very helpful in the initial search for a floe and in studying the drift of APLIS in late July.

Some representative photographs are included in Figures 41-44 to show the ice conditions during the spring and summer. This information will be helpful in understanding the changes in water properties.

T-S Diagram

Figure 45 is a temperature-salinity (T-S) diagram plotted to aid in tracing the water masses. The arrows indicate one of three possible origins of the warmer water (these possibilities are discussed in Section V).

There are several CTD profiles that seem to contain mid-depth water that has cooled to near freezing during the winter. In the T-S diagram, these layers appear within the area labeled "Chukchi winter water." At several locations along the Barrow Canyon, the profiles show cold water on the shoreward side that seems to have drained from the shallower portions of the Chukchi Sea. These layers appear in the area labeled "drainage of bottom layers from Chukchi Sea."

Some of the deep profiles northeast of Barrow showed a layer of warm, saline water at the bottom which is generally known as Atlantic water. These measurements are connected by a line which merges into a profile taken at 75°N, 147°W in the Beaufort Sea in 1972. The warm intrusion through Bering Strait is too warm to be shown on the T-S diagram, but four points are plotted that indicate the forefront of this intrusion.

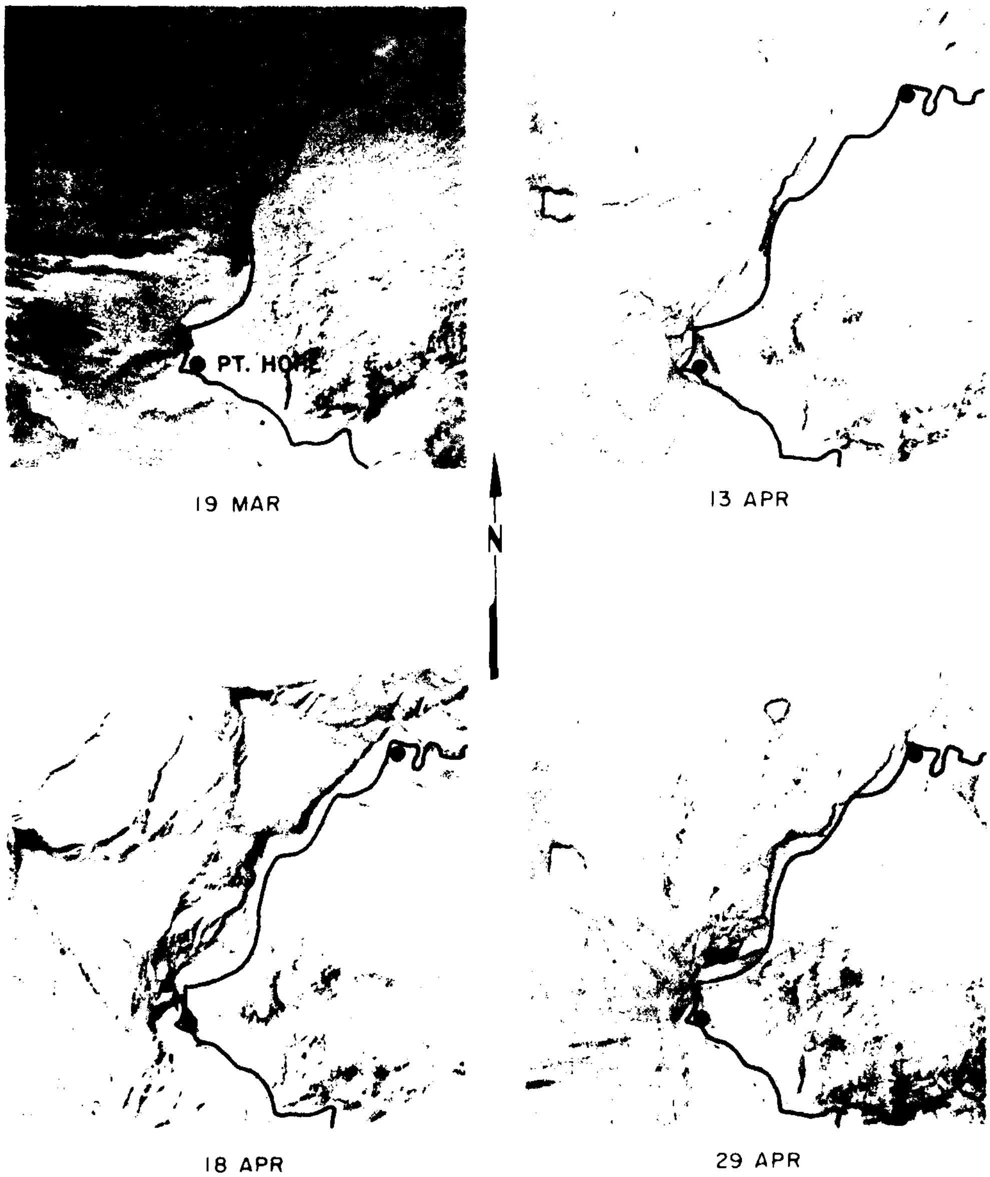
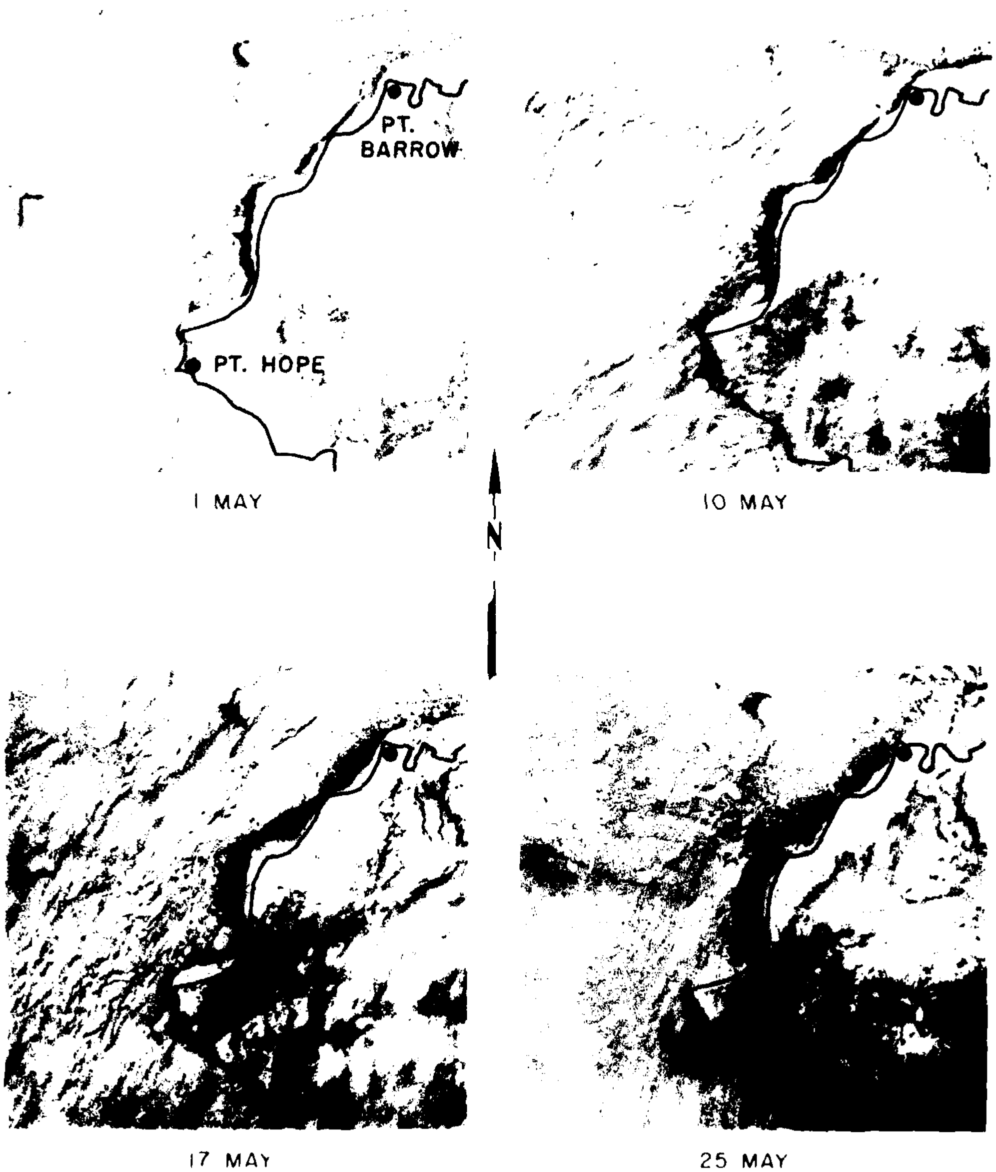


Figure 41. [illegible] photographs of the eastern [illegible] [illegible]


PT. BARROW
PT. HOPE
1 MAY
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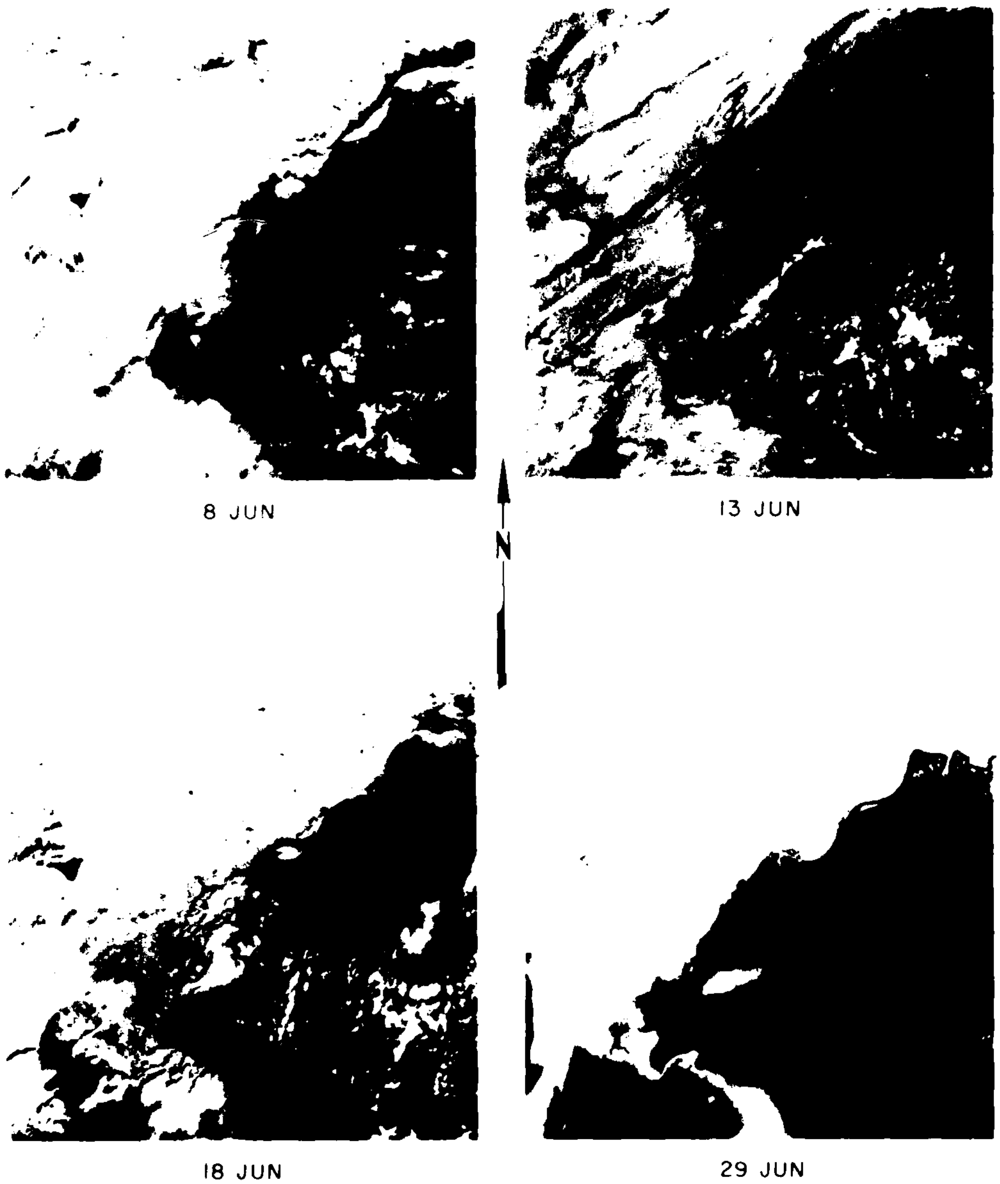
17 MAY
25 MAY


8 JUN
13 JUN
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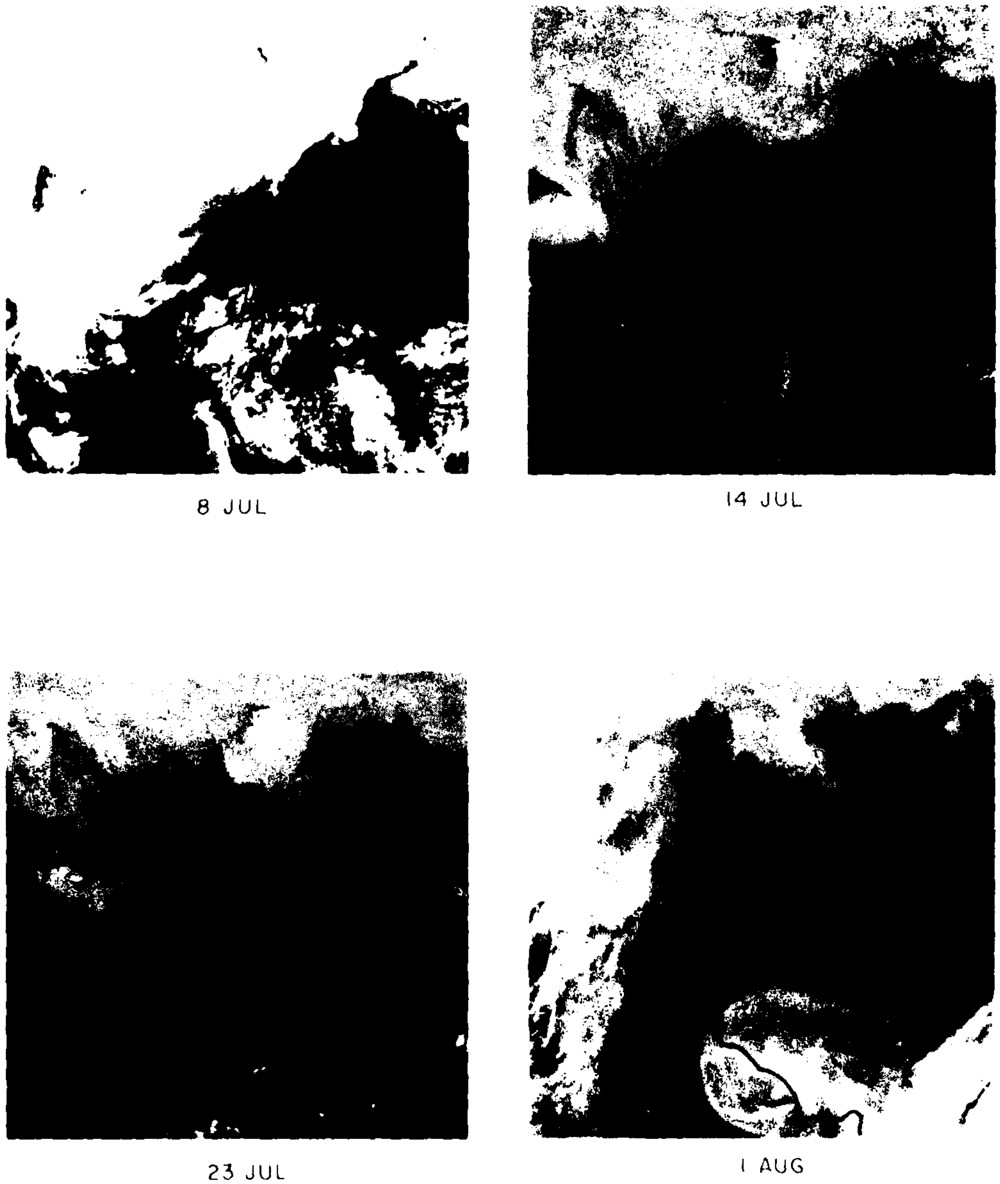
18 JUN
29 JUN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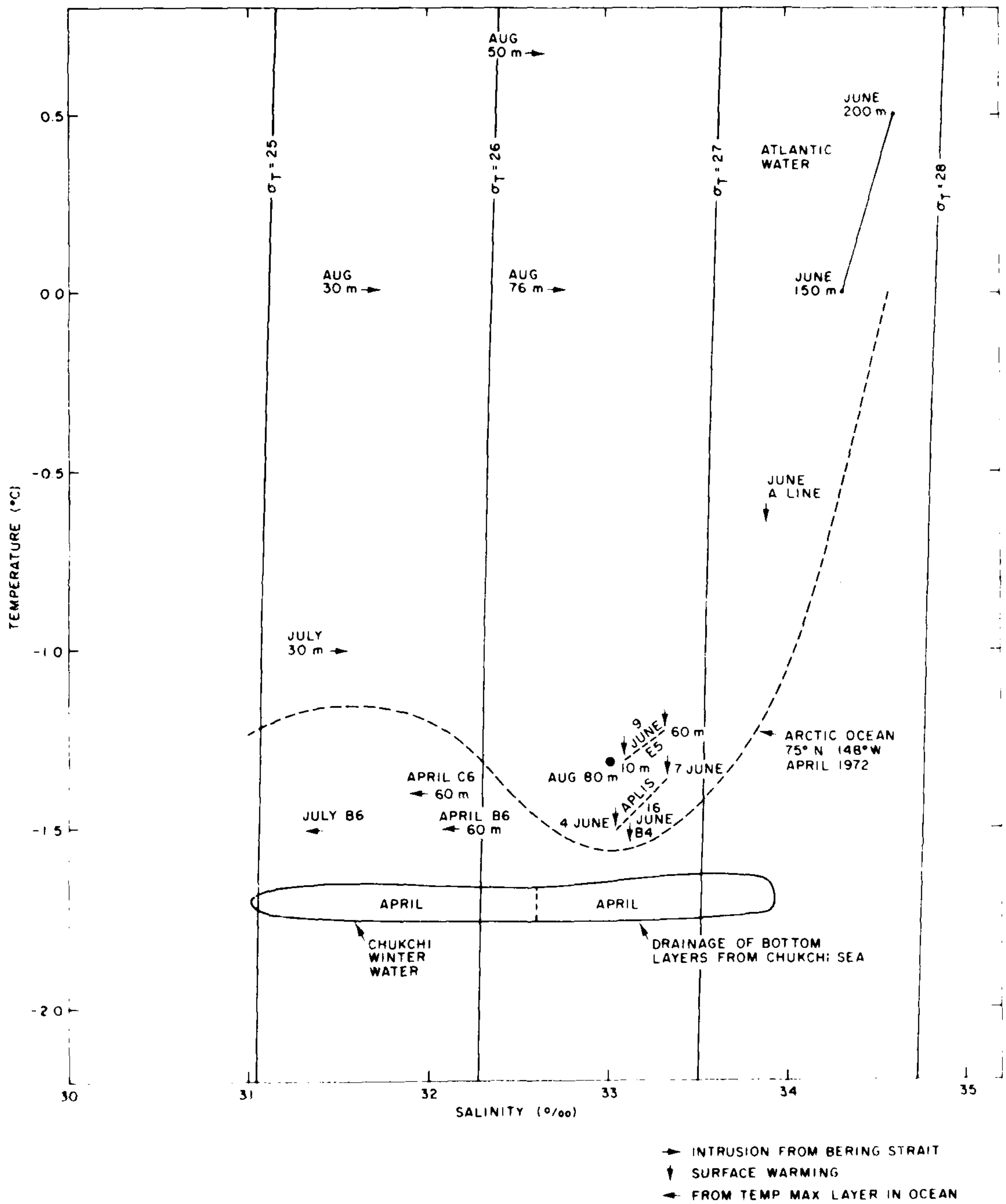

Figure 46. Temperature-salinity diagram for the principal water masses encountered during summer 1977.

V. DISCUSSION

Many of the phenomena observed in 1977 were observed to some extent in previous years.[1-5] However, the new data allow a better understanding of the water movements and changes in properties. It appears that some of the explanations presented earlier for these phenomena may require changes while others are reinforced. The following paragraphs discuss how the present measurements apply to phenomena observed and reported during the past few years.

Changes in the Coastal Shallows

In last year's report,[5] we offered the following explanation for the cold, saline bottom layers observed in the eastern Chukchi Sea: This type of water is created in the shallow areas of the Chukchi Sea during winter when the surface freezes, with subsequent settling down slope. The shallower the area, the higher the salinity that will be produced in the underlaying waters for a given amount of ice formation. High-salinity water formed in the shallows eventually moves by convection beneath the existing waters and forms a bottom layer somewhat more saline than the waters above.

During the helicopter surveys in April and June, we made a special effort to take stations very close to shore in an attempt to trace this movement. Because helicopter support was unavailable in May, we were unable to follow the process in detail, but we did observe some of the stages.

The CTD measurements in the shallow areas revealed some very high salinities. The line off Icy Cape on 13 April (Figure 5) showed a maximum salinity of 32.8‰ in 20 m of water near shore. On the same date, the line off Pt. Franklin (Figure 6) showed a maximum salinity of 33.5‰ for a thin bottom layer at station B1 in the shallows near Pt. Franklin. The temperature was warmest along the bottom. At this time, the area was ice covered with a break along the shore.

In 1975, a bottom layer was found that was warmer than the water above it. We have previously suggested[4] that this warm bottom layer might have been formed by solar warming of the high-salinity coastal water before it had settled and spread along the bottom of the Chukchi Sea.

In April 1977, there was only a slight indication of warming. Figure 6 shows temperatures of -1.65°C along the bottom near Pt. Franklin on 13 April. The satellite photographs (Figures 41 and 42) show that the area remained ice covered, except for breaks along the shore, through April. In May the ice moved away leaving a wide, open area along the coast, which remained open through the month.

The next measurements near Icy Cape (17 June, Figure 11) showed that the entire 20 m of water had warmed to -1.5°C and some of it to -0.5°C. The salinity of this water was mostly between 33.0 and 33.9‰.

Table 25 in The Oceans[11] predicts a total radiation of 0.269 cal $cm^{-2}min^{-1}$ reaching the sea surface at 60°N in May. If we reduce this for the higher latitude and assume open water for 20 days, we obtain about 5000 cal of radiation per square centimeter. Table 27 shows that the percentage of solar radiation reaching 1 m depth in the clearest oceanic water is 26.7%. If we assume that the heat absorbed in the upper 1 m is lost by back radiation, conduction to the atmosphere, and evaporation, the average temperature rise in 20 m of water due to the absorption of the heat passing below 1 m would be approximately

$$\frac{(5000)(0.267)}{2000} = 0.7°C$$

Therefore, solar radiation could account for most of the temperature rise from -1.7°C in April (Figure 5) to -1.0°C in June (Figure 11) that was observed in the 20-m deep area along the coast at Icy Cape.

This warm saline water in the shallows would have a tendency to settle down slope during the next few weeks. However, the measurements from the BURTON ISLAND in July showed no warm bottom layer. Although the process that we wished to document seems to have started, there was apparently too much mixing as the warm saline water settled down slope to form a warm layer along the bottom as was observed in 1975.

Chukchi Sea Drainage

In 1975[4] we observed large regions of cold water to depths of 180 m off the mouth of the Barrow Canyon. We corroborated the suggestion by Paquette and Bourke[12] that this water represents drainage from the Chukchi Sea via the Barrow Canyon.

In 1976[5] the path of the drainage in April was followed from Wainwright into the Arctic Ocean well beyond the canyon's mouth. At that time, the drainage held to the shoreward side of the canyon.

The 1977 measurements showed a uniform layer along the bottom on the shoreward side of the canyon in April, but the salinity was not very high (32.75‰). By the middle of June, the entire water mass off Icy Cape had a salinity of 33.2 to 33.8‰ (Figure 11). Off Pt. Franklin, almost the entire water mass between the shore and the canyon was at 33.2‰ (Figure 12). It appears that in June a large accumulation of the high-salinity water was moving toward the ocean while remaining close against the coast. Some of this flow was evident off Pt. Barrow (Figure 13).

The measurements along the south side of the Barrow Canyon on 13 June (Figure 16) showed that nearly the entire depth (to 180 m) was filled with cold, saline water. Most of it had a salinity above 33‰ and can be considered to be an accumulation of drainage water.

Station E12 (Figure 17) northeast of Pt. Barrow on 27 June shows a layer of cold water between 135 and 180 m with a nearly constant salinity of 33.9‰; this layer represents drainage from the Chukchi Sea which has displaced the warmer Atlantic water that would ordinarily be observed above 180 m.

In July, a section north-northwest from Pt. Barrow (Figure 20) shows none of this drainage water because it has been displaced by the intrusion from Bering Strait. However, a section northeast of Pt. Barrow (Figure 19) shows a layer of cold, saline water (-1.6°C, 33.6‰) that lies above the Atlantic water and appears to be an accumulation of drainage water. Similar water fills the lower portions of the canyon (Figure 22).

The oxygen measurements (Figure 40) confirm that the deep, cold water northeast of Pt. Barrow has recently come from the surface, not from the Atlantic water near the bottom.

In summary, in April we found a bare start of the Chukchi drainage. By mid-June the drainage was well developed; it was close against the shore and up to the surface, and extended a few miles east of Pt. Barrow. By 27 June, a large accumulation of drainage existed between 135 and 180 m near the mouth of the Barrow Canyon. By July, the accumulation had spread 70 n.mi. (130 km) northeast of Pt. Barrow and was being disrupted from above by the warm intrusion from Bering Strait.

Warm Water on the Shelf in the Spring

On 29 April 1972, a pocket of relatively warm water (-1.4°C) was found in the vicinity of the Barrow Canyon at 30-m depth.[3] In April 1974, a series of profiles taken 15 n.mi. (28 km) northeast of Pt. Barrow showed finestructure with a temperature as high as -1.4°C at depths of 30-80 m (see Figure 28 in Reference 3). The sharpness of these layers indicated recent, nearby formation. The warmer water apparently came from the temperature-maximum layer of the Arctic Ocean, a relic of the Bering Sea intrusion the preceding summer[13] that survives the winter cooling.

Measurements along the coast from Pt. Barrow to Wainwright in April 1976 showed a warm layer (-1.5 to -1.0°C) occurring all along the coast at depths of 50-90 m. This layer appeared to be a movement of water from the temperature-maximum layer of the Arctic Ocean into the Chukchi Sea via the Barrow Canyon. It was counter to the drainage of Chukchi Sea bottom water into the ocean and, when overlapping it in depth, was farther from shore.

The present measurements found several instances of warm water along the coast before any possible arrival of the summer intrusion through Bering Strait.

On 10 April, water at -1.5°C (S = 32.0‰) was found at 60 m depth off Pt. Franklin (see Figure 7). Water that warm was not observed on the Icy Cape line farther up the canyon (see Figure 6). A line of stations off Pt. Barrow (Figure 8) showed -1.5°C water with a salinity of 32‰ at two stations, C5 and C6. Well north of the canyon, at a depth of 50-60 m, and with no increase of salinity corresponding to the warm Atlantic water in the Arctic Ocean, it could not have come from an upward surge of that water. The angle of the CTD cable at stations C5 and C6 indicated a southwesterly current. Thus, the -1.5°C water appears to be a movement from the temperature-maximum layer in the Arctic Ocean across the sill formed by the ridge north of the canyon. Some of this water was observed at the same depth off Pt. Franklin.

On 16 June, one station off Pt. Franklin showed water with a maximum temperature of -1.45°C, with adjacent stations at -1.7°C (see Figure 12). The satellite photograph for 8 June shows an open lead near this station, and the warmth may be due to solar radiation. There is no indication in the isohalines of any water movement.

The section off Pt. Barrow on the same date (Figure 13) shows a warmer (above -1.6°C) water mass which is bounded on the shoreward side by the colder, higher-salinity Chukchi drainage. Stations E6 and E7 farther east (Figure 14) showed more of this warm, low-salinity water in the upper 50 m. This warm water is thought to come from the temperature-maximum layer.

At ice camp APLIS, the water temperature at 14 m depth suddenly rose to -1.5°C (with S = 33.0‰) near 4 June (see Figure 31). This rise is most likely due to surface-warmed drainage from the Chukchi Sea. There was a strong southerly current preceding the temperature peak (27, 28 May; Figure 32).

By late July, the annual intrusion of warm water from Bering Strait had penetrated the region and it was not possible to differentiate this water from the warm water coming from the temperature-maximum layer. The higher temperatures near the surface (-1.0 to 0°C) are definitely not from the temperature-maximum layer in the ocean.

Surges of Atlantic Water

During our oceanographic measurements along the coast in the eastern Chukchi Sea, we have occasionally observed waters with a temperature and salinity similar to those of Atlantic water.

On 19 September 1974, a line of profiles across the Barrow Canyon showed a rise in both temperature and salinity over the canyon, as though water had surged up the canyon (see Figure 51, Reference 3).

Measurements in April and May of 1975[4] showed an uprising of Atlantic water into the Barrow Canyon. There was no indication of whether this water resulted from a sudden surge or a slow progression. For a 1-month interval between surveys, movement appeared to be up the slopes in a westerly direction (see Figure 15 of Reference 4). A layer with a temperature of -1°C and a salinity of 34‰ was found at a depth of 120 m near the mouth of the canyon. This layer was a 10-m thick anomaly in the surrounding -1.7°C water. Many other layers were found at lower depths that appear to be Atlantic water interacting with the Chukchi drainage.

Bourke and Paquette have suggested[7] that the warm bottom layer they observed in 1975, which was slightly warmer than the usual Chukchi Sea winter water, was mostly Atlantic water that had surged up the canyon. We have postulated[4] that this warm bottom layer was formed by the solar heating of high-salinity water in the shallows along the coast; the observations discussed at the beginning of Section V support this theory.

The present measurements show, in April, a layer of water in the bottom of the canyon off Pt. Barrow (at a depth of 130 m) that had a temperature of -0.6°C and a salinity of 34‰; these properties resemble those of Atlantic water found at about 180 m in the Arctic Ocean. This water has apparently advanced up slope, but there is no indication of a sudden surge. Although several examples of shallower water with a temperature and salinity approaching those of Atlantic water were observed (see Figures 12, 14, and 26), it appears that they were formed from either Chukchi drainage that had been warmed beneath open leads or an intrusion of the temperature-maximum layer.

Oxygen measurements were taken to explore the theory that the deep Atlantic water would have a lower oxygen content than the other water masses, and that any Atlantic water brought to shallower depths would also have less oxygen. The first assumption was verified. Samples of Atlantic water from 210-225 m consistently showed a low oxygen content, with an average saturation of 71.5%. Samples taken from the Chukchi drainage water showed a saturation of about 80%; samples taken near the surface averaged 90%. The spread appeared to be adequate to identify a water's origin by its oxygen content.

Samples were taken for oxygen analysis whenever increases in water temperature and salinity appeared at APLIS. Unfortunately, the spread in the values for water samples taken from the same bottle was so great that the results must be considered unreliable. Some values as low as 50% were obtained, and these are difficult to explain. The only consistent results at APLIS are for samples 112 and 113, which were taken from water with a temperature and salinity similar to those of Atlantic water at a time that coincided with southerly currents and low air pressure. These samples show an average oxygen saturation of 88%, too high for this to be Atlantic water.

VI. REFERENCES

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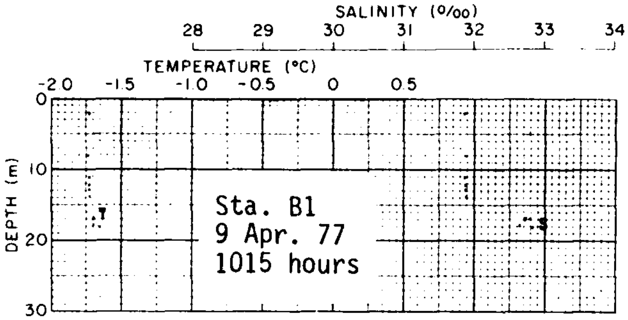
APPENDIX A

CHUKCHI SEA OCEANOGRAPHIC DATA OBTAINED IN APRIL 1977

CTD profiles were taken along several lines perpendicular to the coast. The locations of the stations for the April survey are shown in Figure 4, p. 11.

Station	Date	Local Time
B1	9 Apr.	1015
B2		1103
B3		1145
B4		1226
B4	10 Apr.	1136
B5		1225
B6		1251
C1		1405
C2		1440
C3		1514
C4		1556
C5		1630
C6		1706

Station	Date	Local Time
B1	13 Apr.	1015
B2		1048
B3		1128
B4		1205
B5		1324
B6		1407
A2		1557
A3		1635
D2	15 Apr.	1454
D4		1645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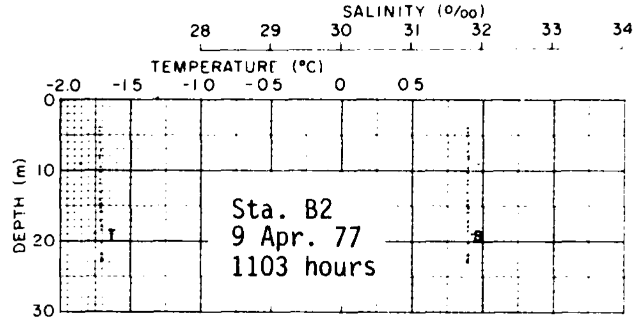
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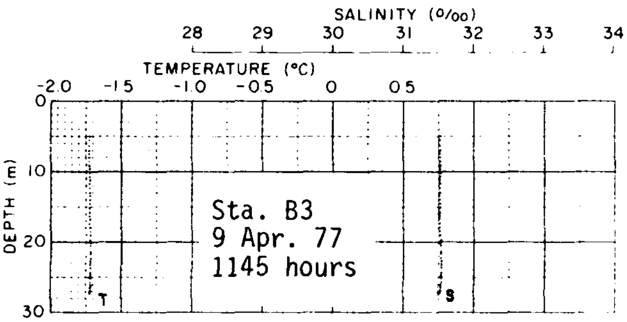
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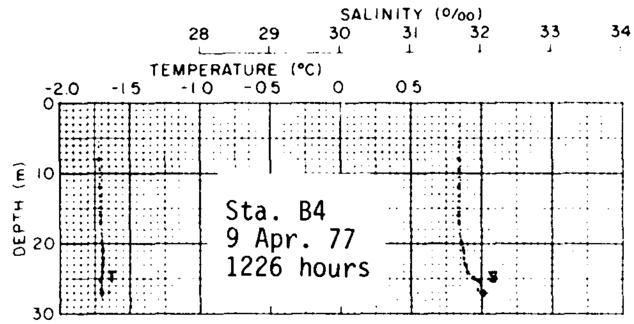
9 Apr. 77
1145 hours
T
S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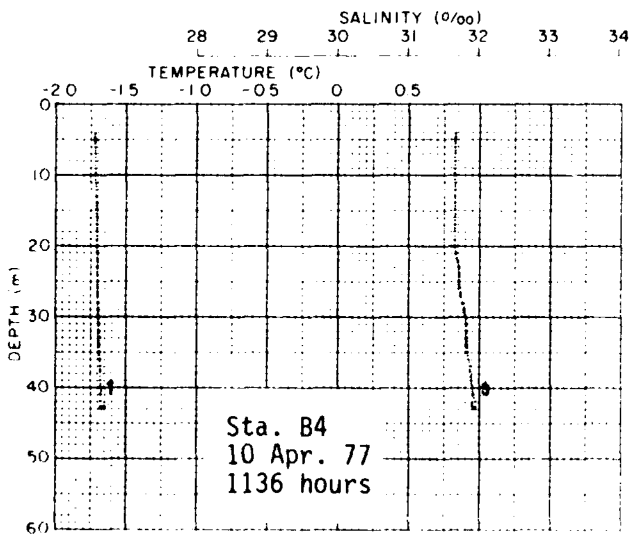
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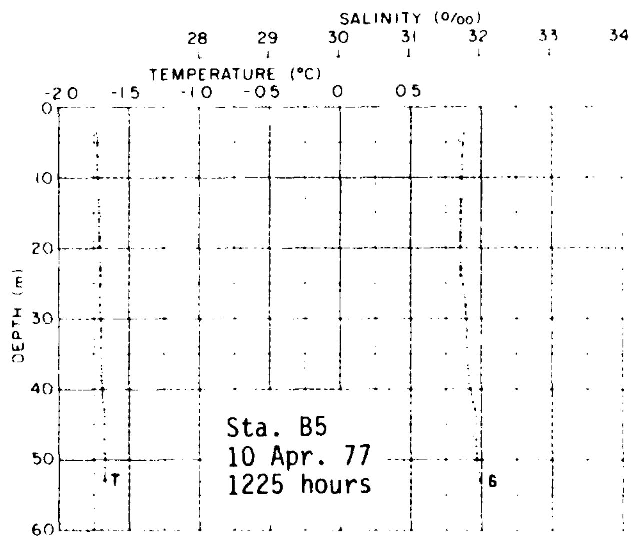
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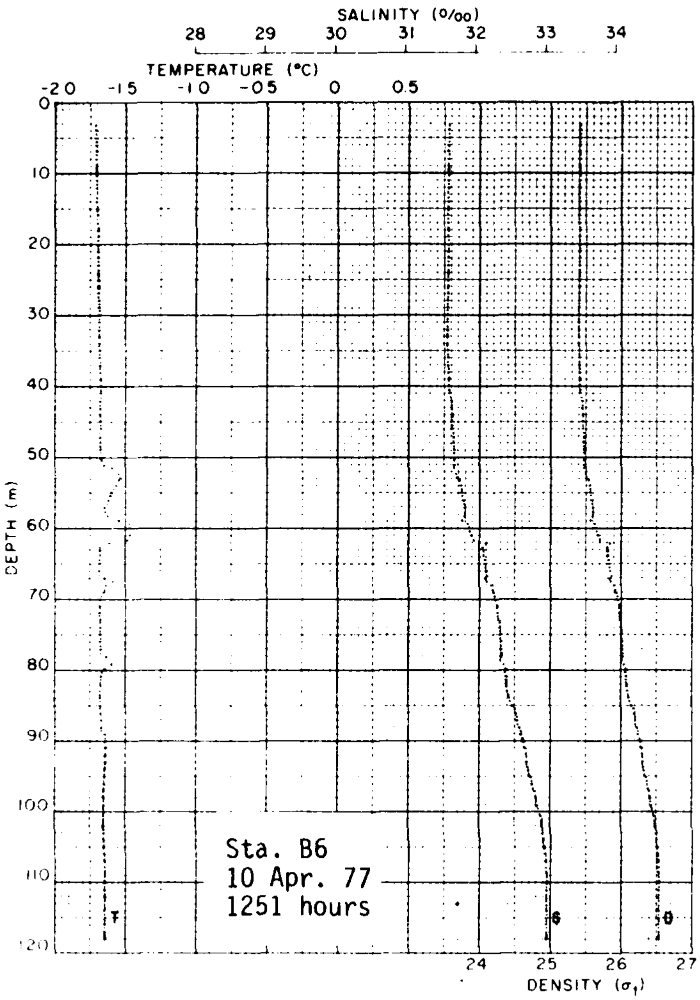
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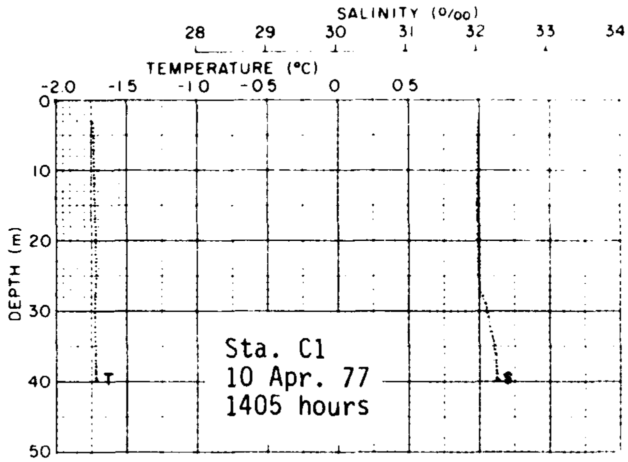
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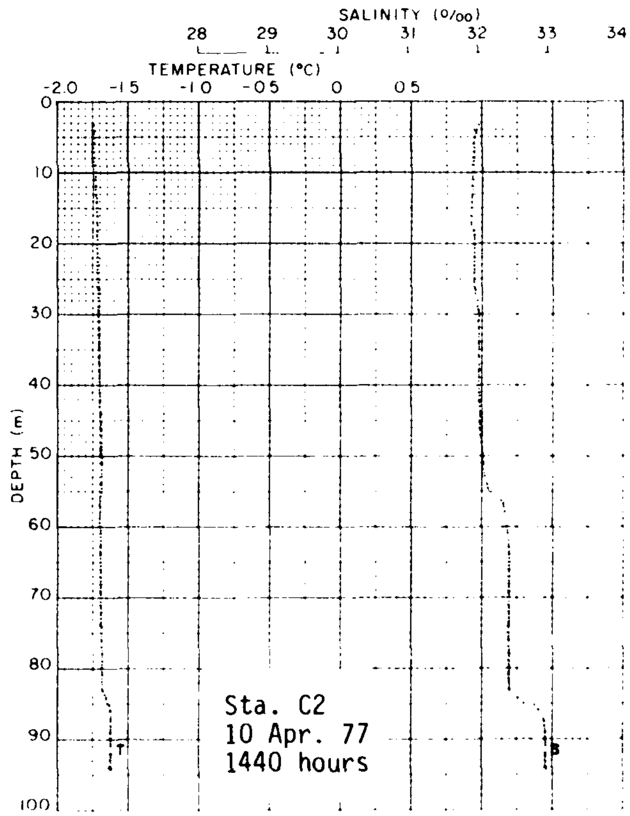
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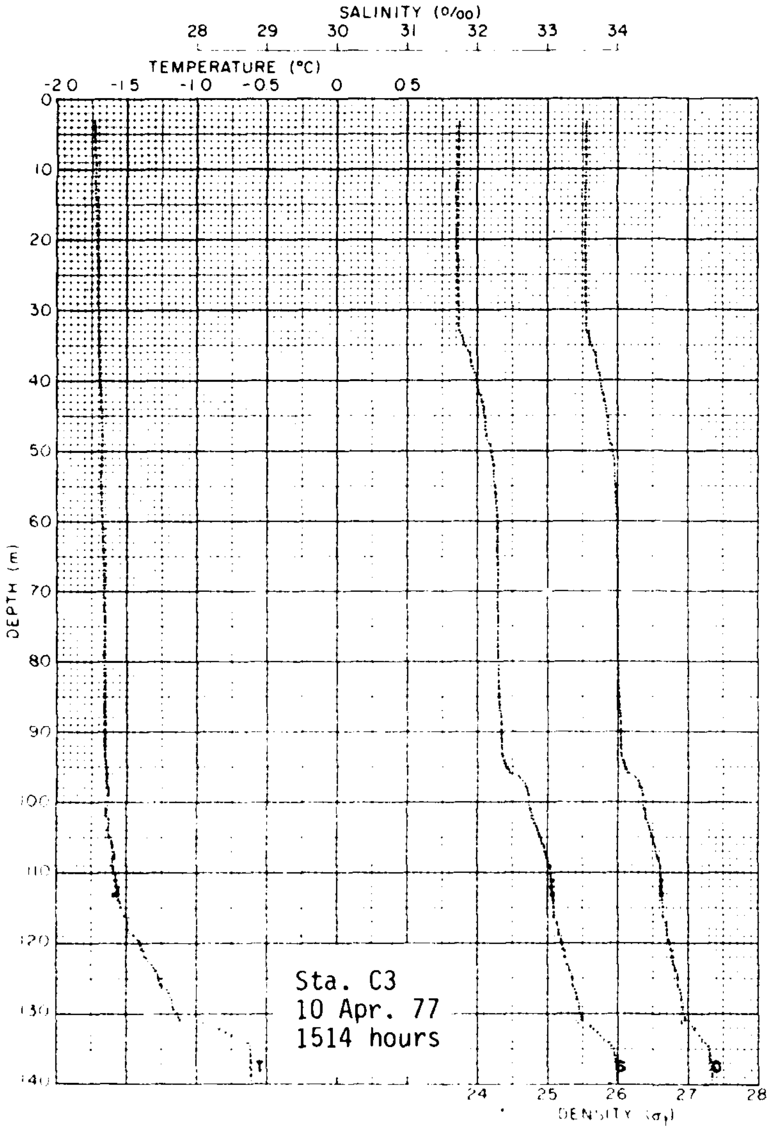
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T
S
D
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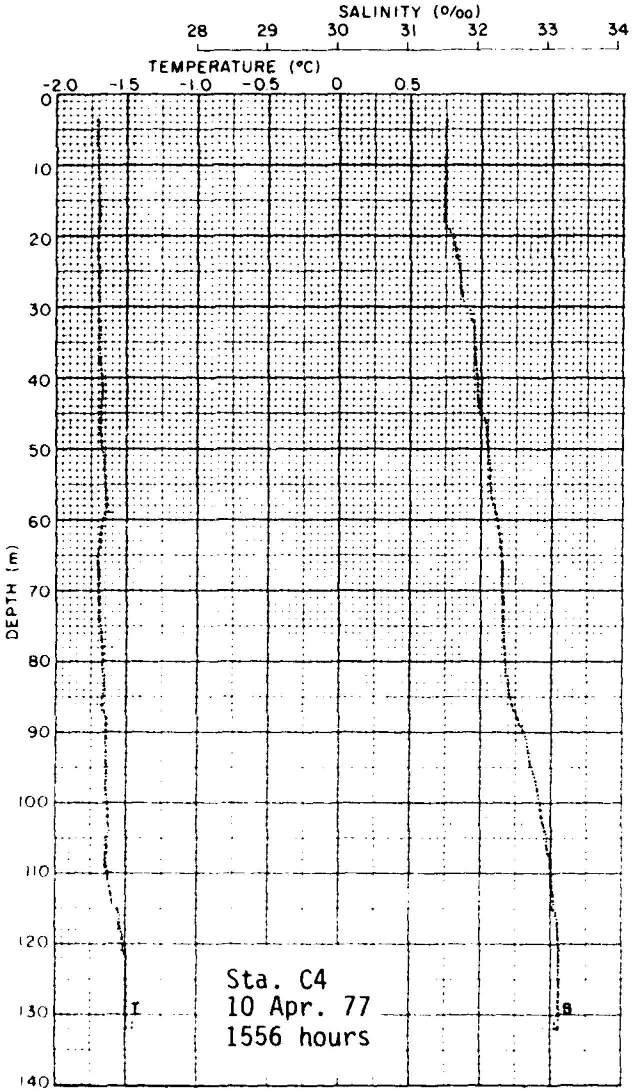
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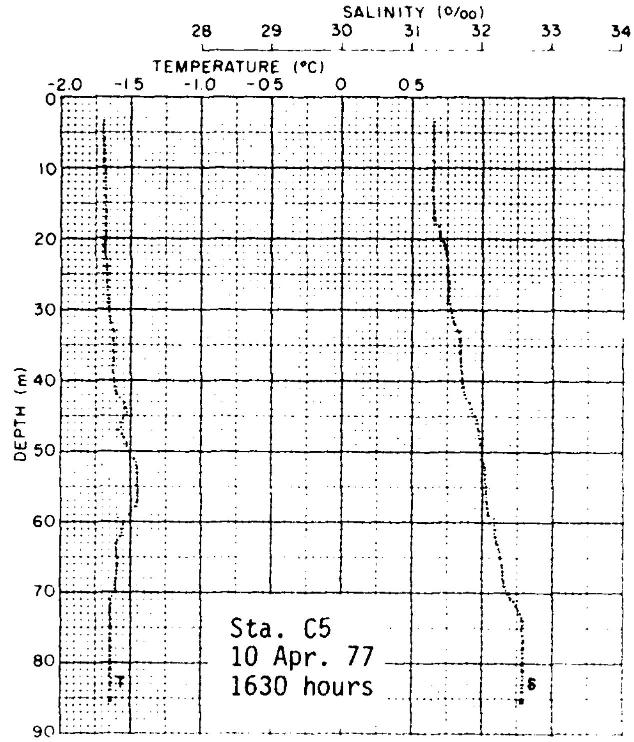
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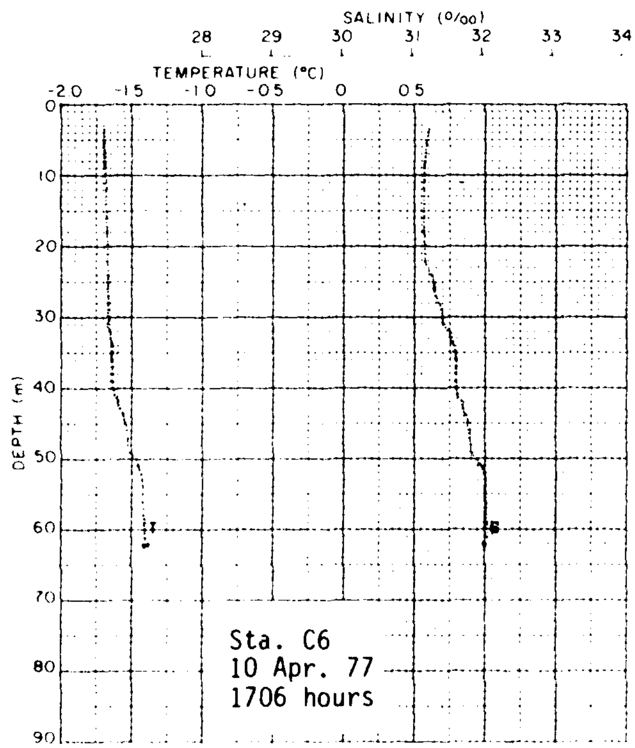
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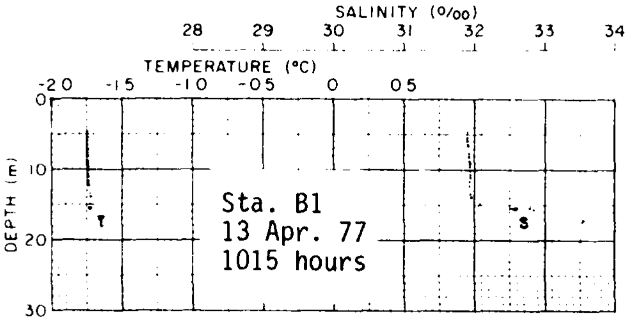
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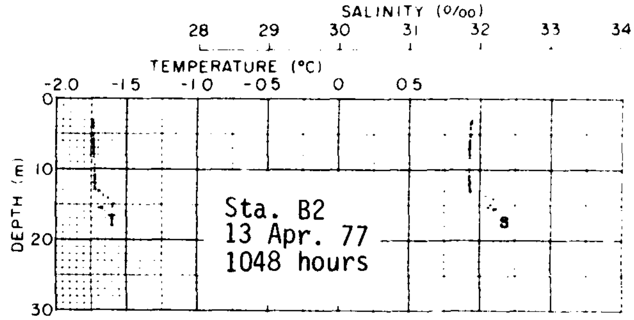
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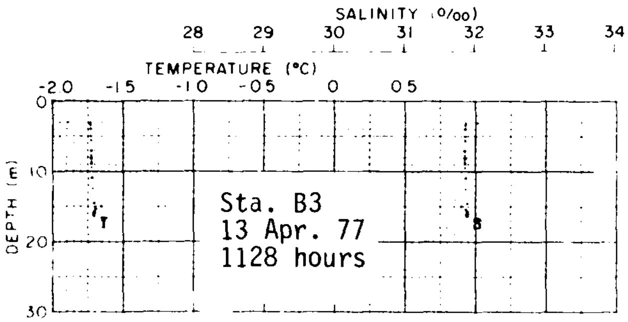
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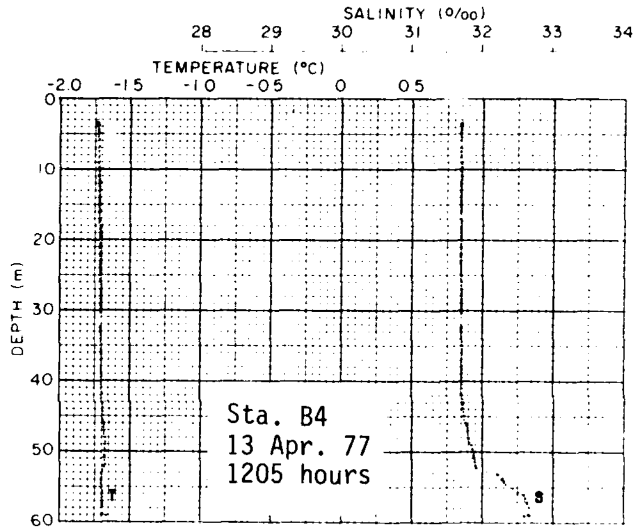
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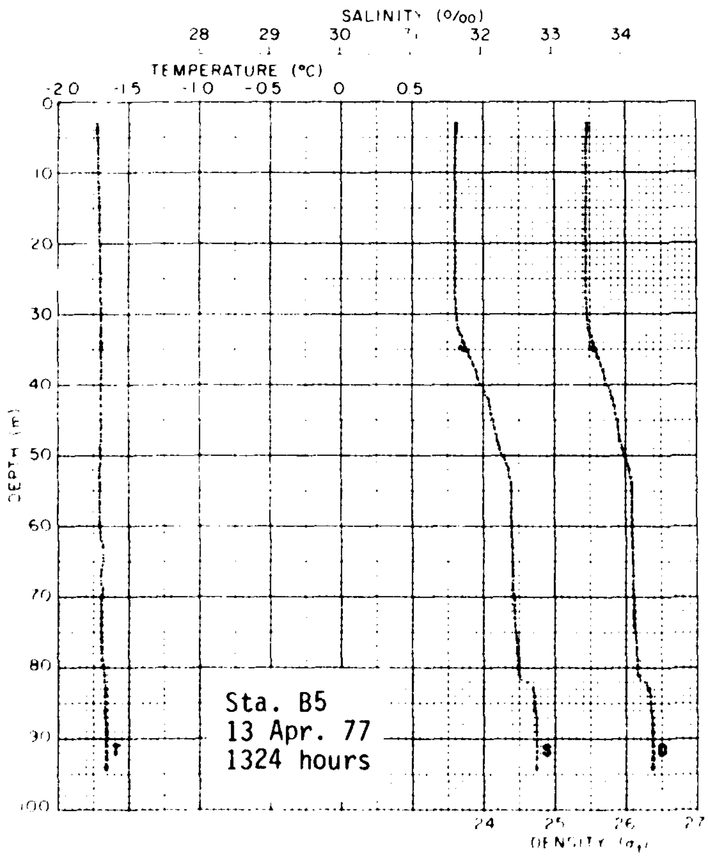
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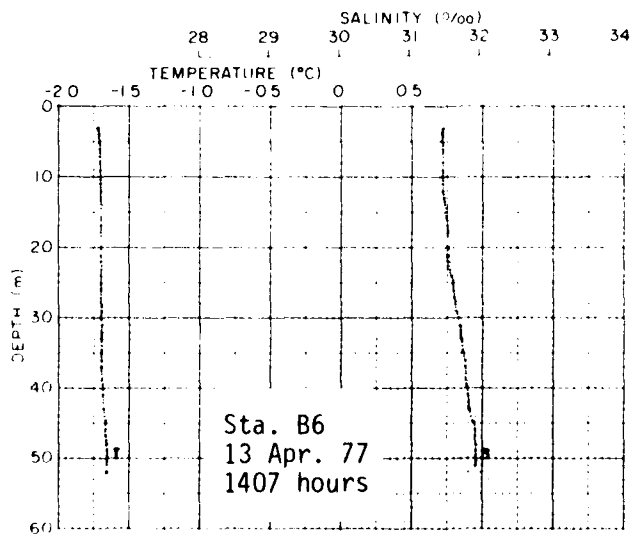
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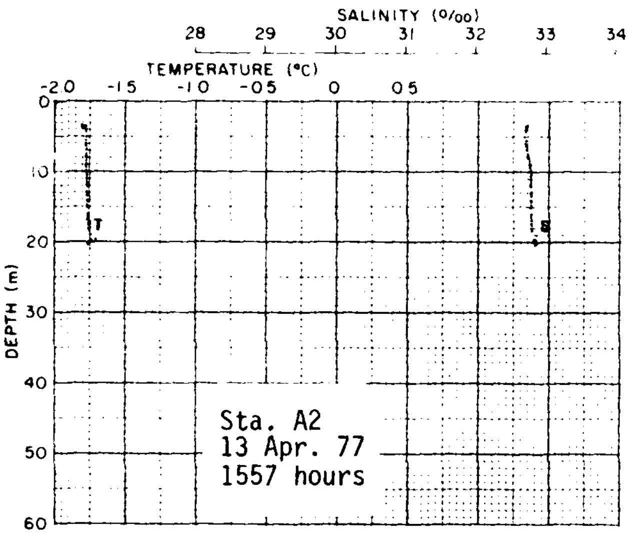
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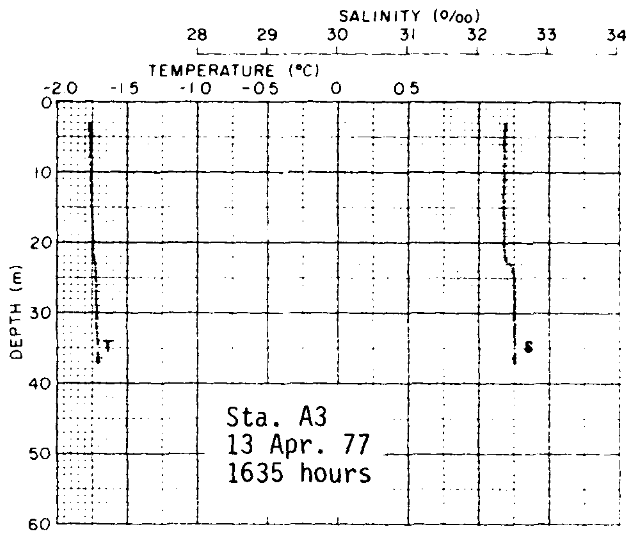
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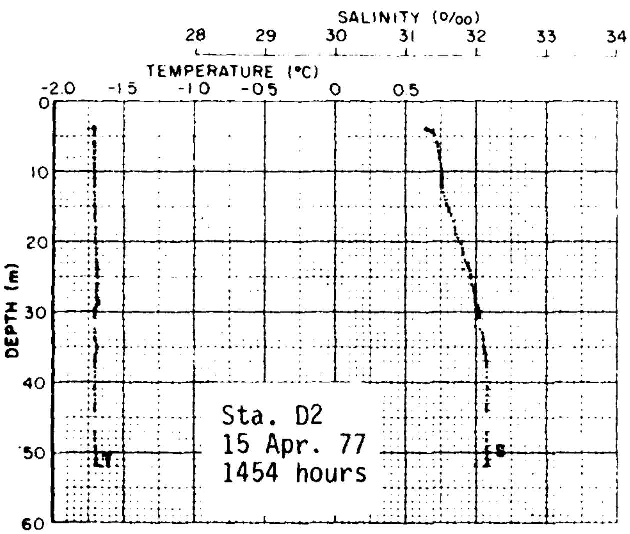
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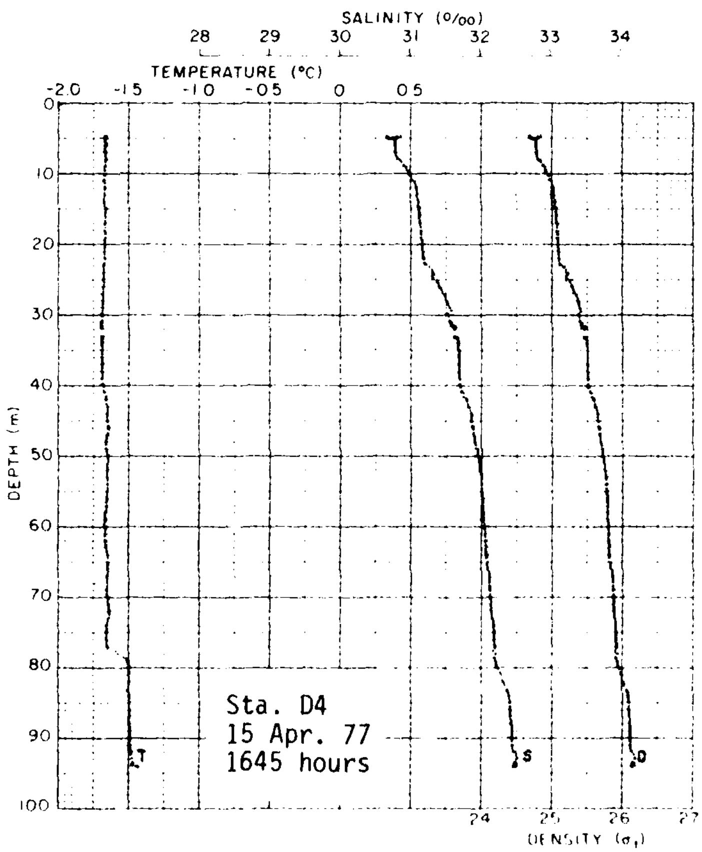
DEPTH (m)
Sta. D2
15 Apr. 77
1454 hours

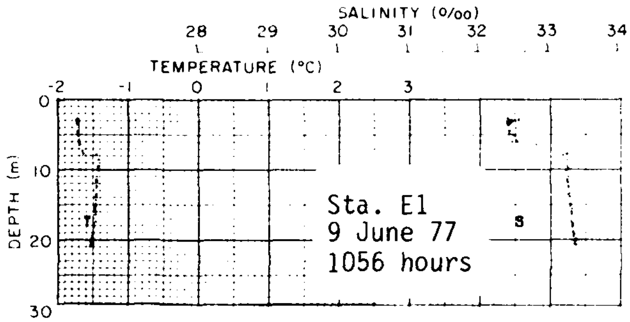

SALINITY (0/00)
TEMPERATURE (°C)
DEPTH (m)
Sta. D4
15 Apr. 77
1645 hours
DENSITY (σt)

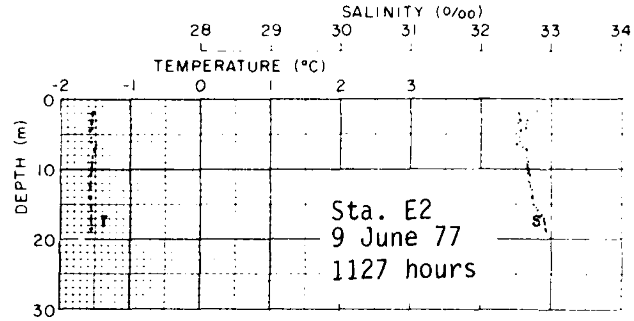
APPENDIX B

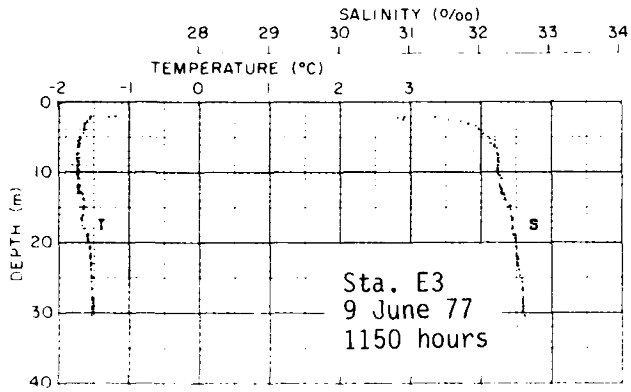
CHUKCHI SEA OCEANOGRAPHIC DATA OBTAINED IN JUNE 1977

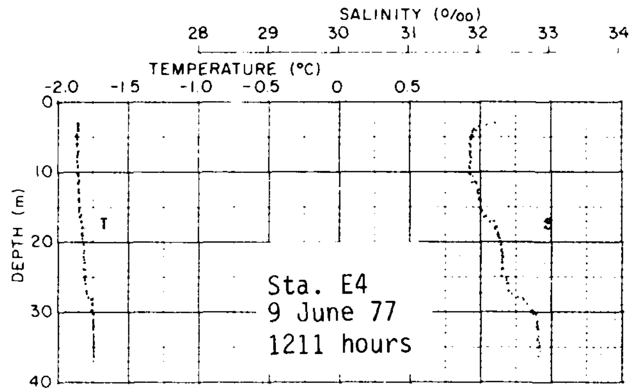
CTD profiles were again taken along several lines perpendicular to the coast. The locations of those stations for the June survey are shown in Figure 10, p. 17.

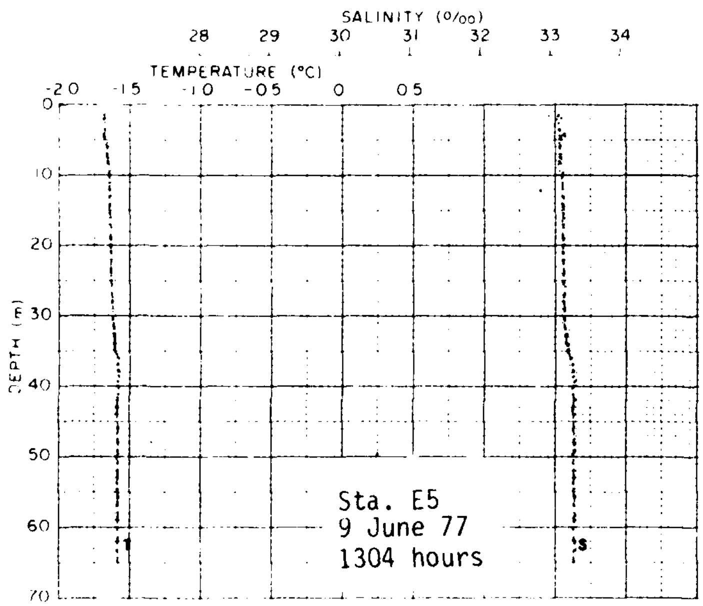
Station	Date	Local Time	Station	Date	Local Time
E1	9 June	1056	C3	16 June	0730
E2		1127	C4		0753
E3		1150	C5		0811
E4		1211	C6		0828
E5		1304	C2		0859
E6	10 June	1530	C1		0914
E7		1645	B1		1105
E8	13 June	1400	B2		1120
E9		1441	B3		1135
E10		1455	B4		1151
E11		1519	B5		1211
			B6		1227
			A1 (dn)	17 June	0840
			A1 (up)		0840
			A2 (dn)		0907
			A2 (up)		0907
			E12	27 June	1604

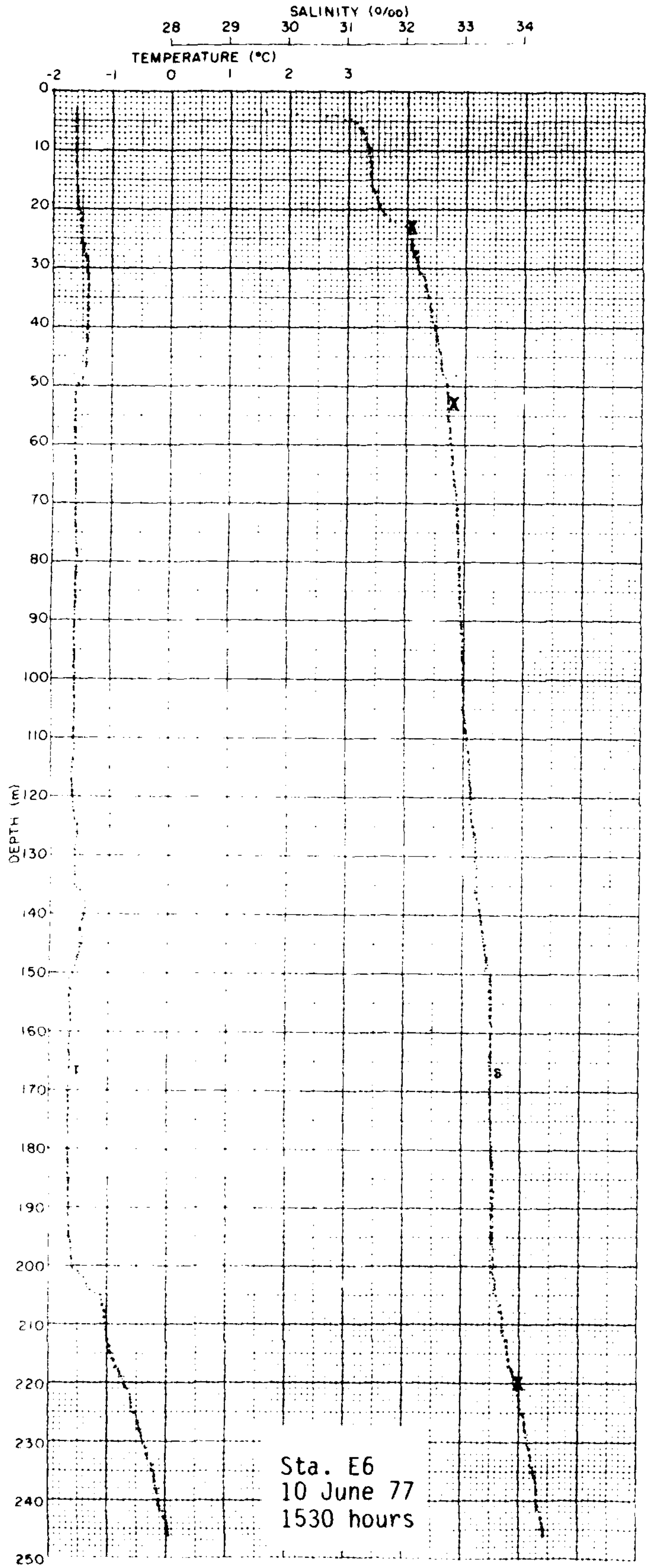

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30
T
S
Sta. E1
9 June 77
1056 hours

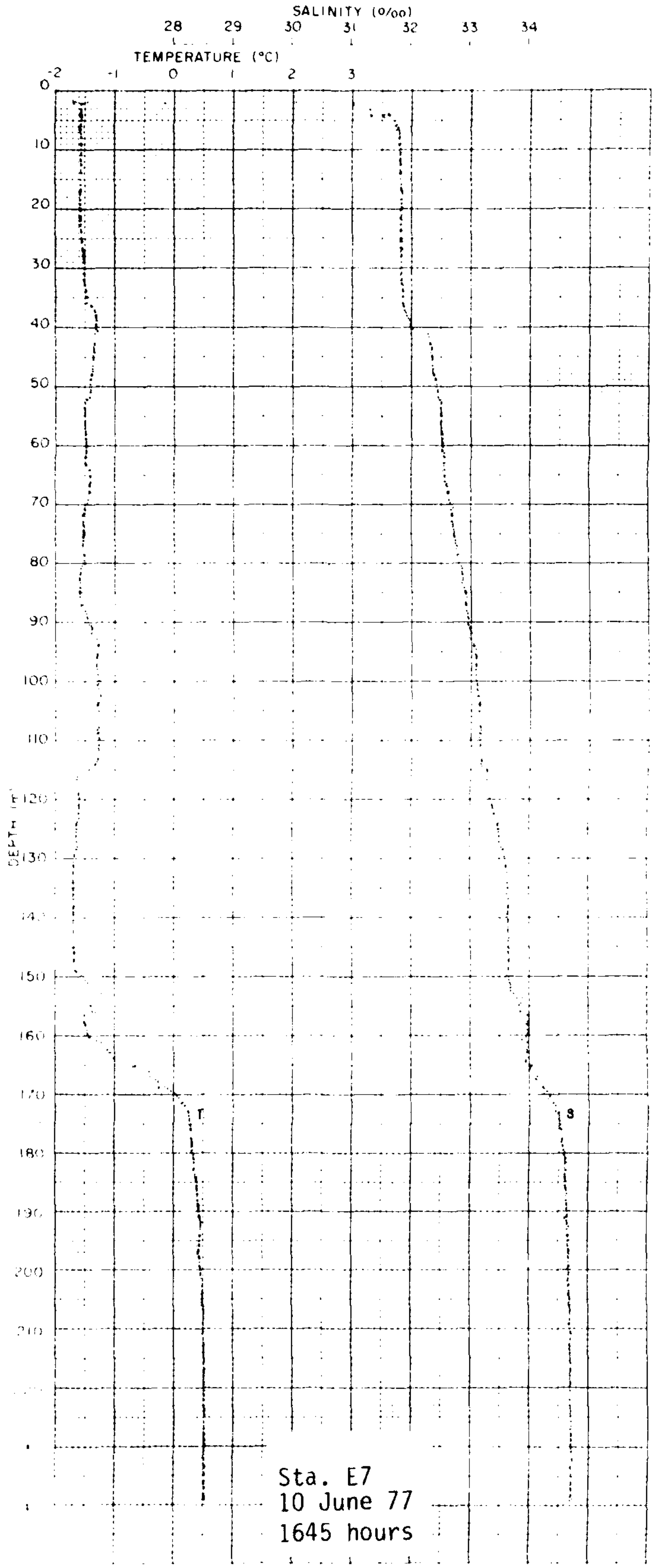

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30
T
S
Sta. E2
9 June 77
1127 hours


SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40
T
S
Sta. E3
9 June 77
1150 hours

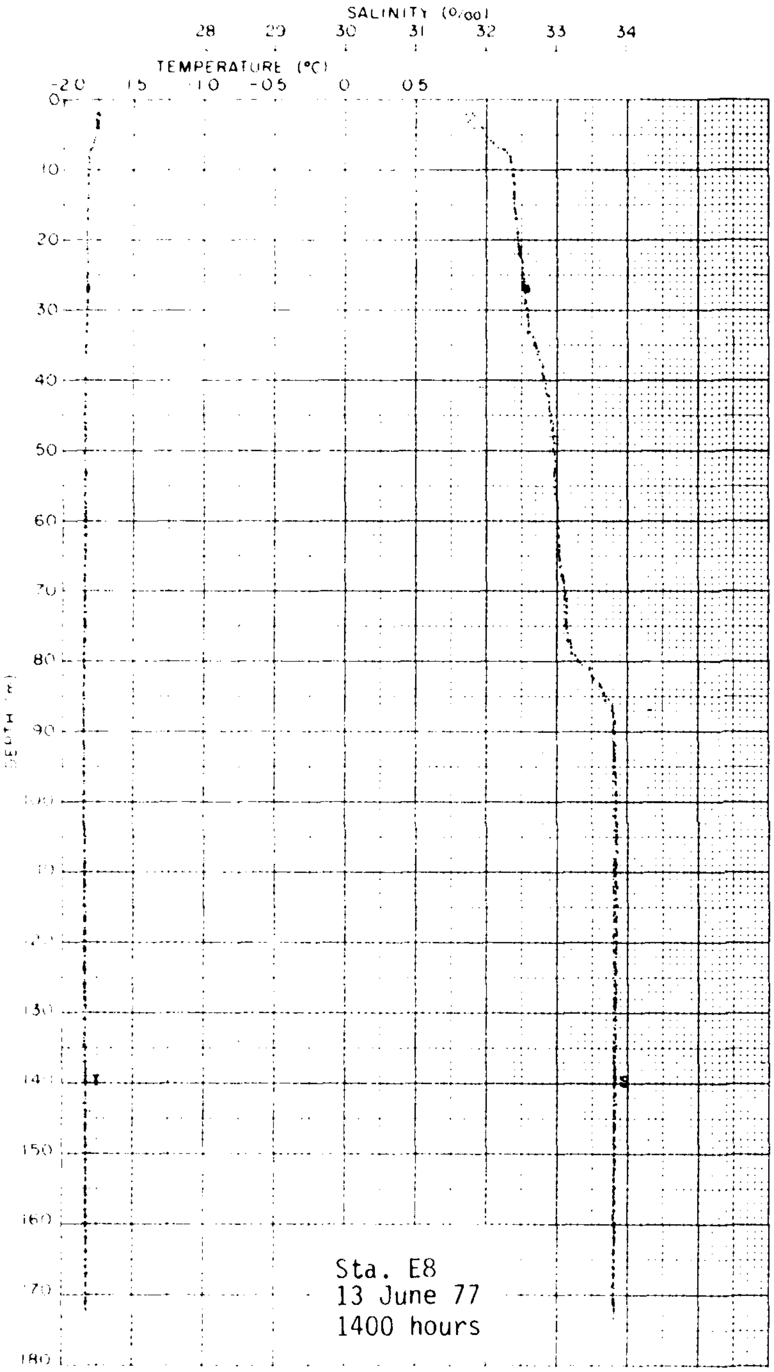

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2.0 -1.5 -1.0 -0.5 0 0.5
DEPTH (m)
0 10 20 30 40
T
S
Sta. E4
9 June 77
1211 hours

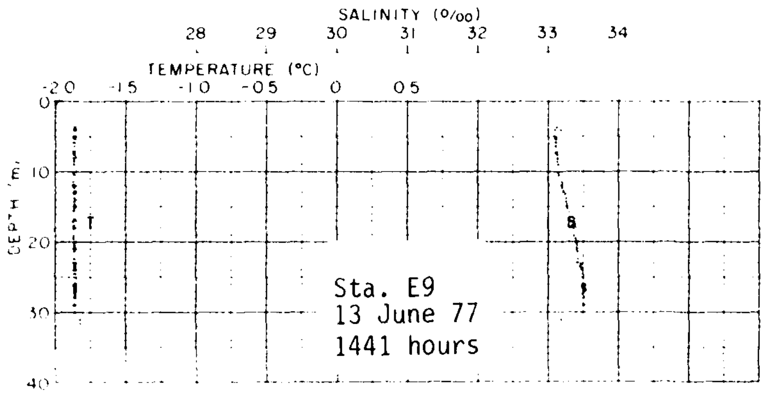

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2.0 -1.5 -1.0 -0.5 0 0.5
DEPTH (m)
0 10 20 30 40 50 60 70
T
S
Sta. E5
9 June 77
1304 hours

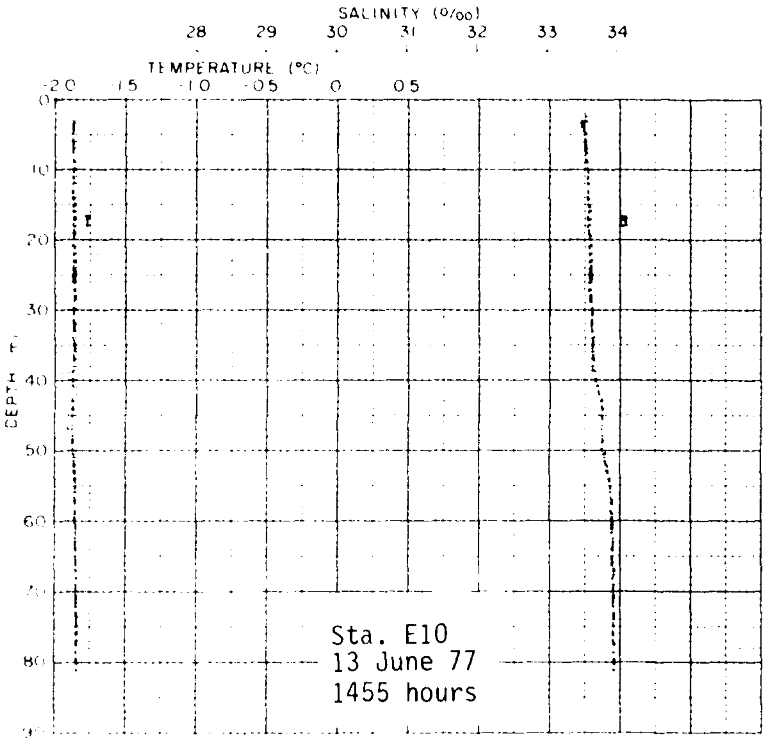

SALINITY (o/oo)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250
T
S
Sta. E6
10 June 77
1530 hours

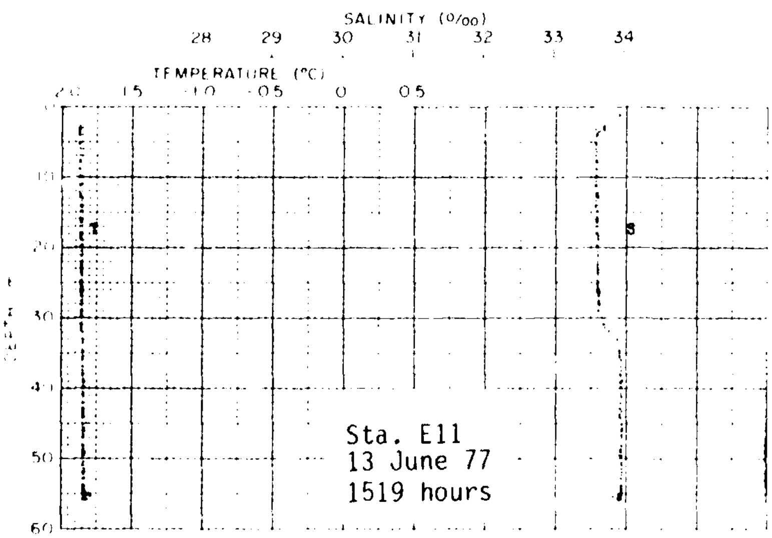


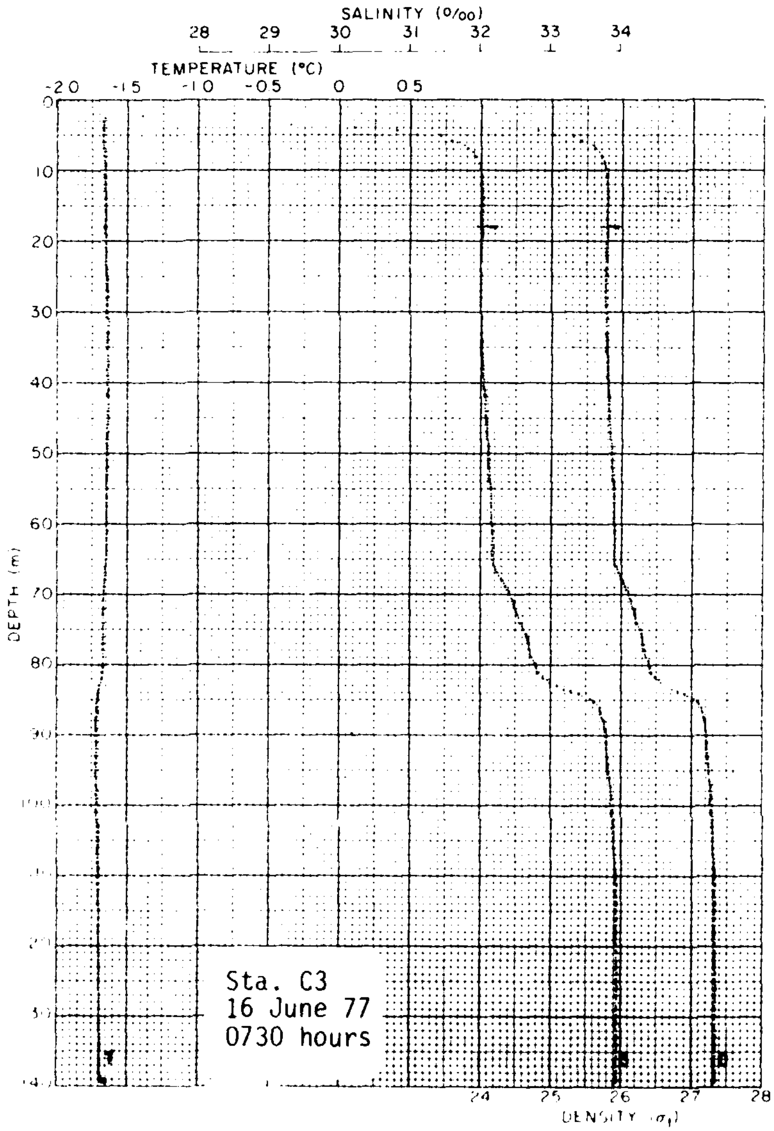
Sta. E7
10 June 77
1645 hours

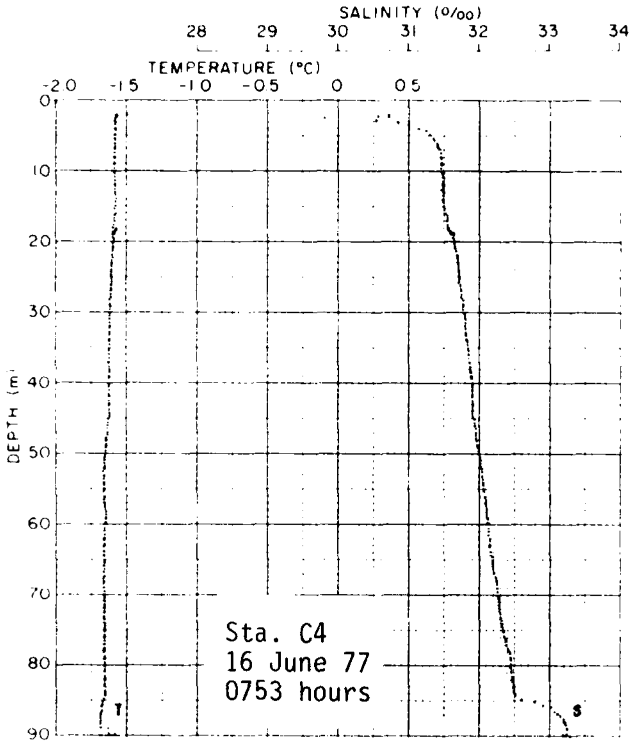

SALINITY (‰)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2.0 -1.5 -1.0 -0.5 0 0.5
DEPTH (m)
Sta. E8
13 June 77
1400 hours

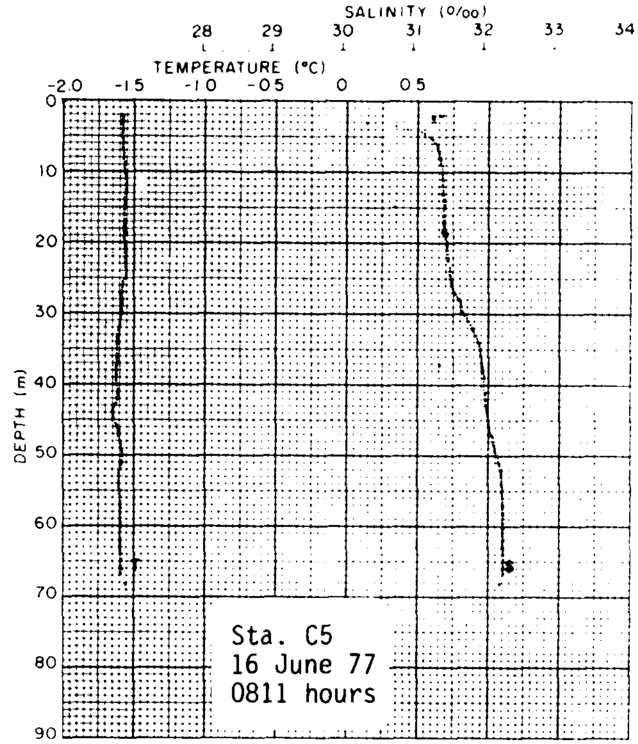

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2.0 -1.5 -1.0 -0.5 0 0.5
DEPTH (m)
0 10 20 30 40
T
S
Sta. E9
13 June 77
1441 hours

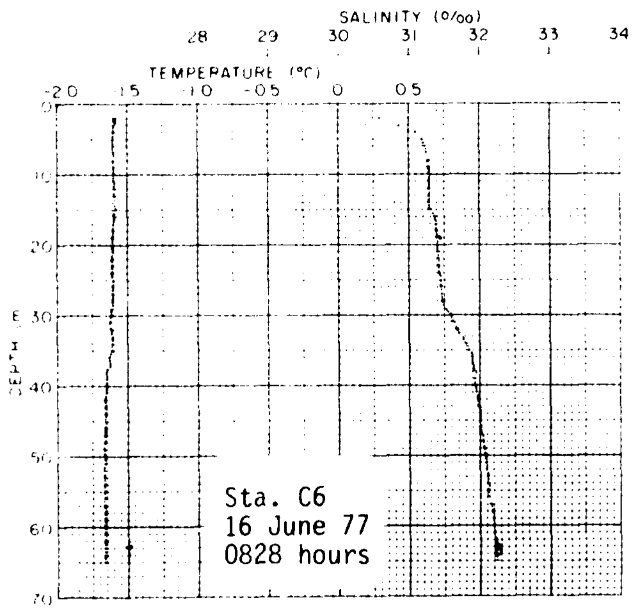

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2.0 -1.5 -1.0 -0.5 0 0.5
DEPTH (m)
0 10 20 30 40 50 60 80
T
S
Sta. E10
13 June 77
1455 hours

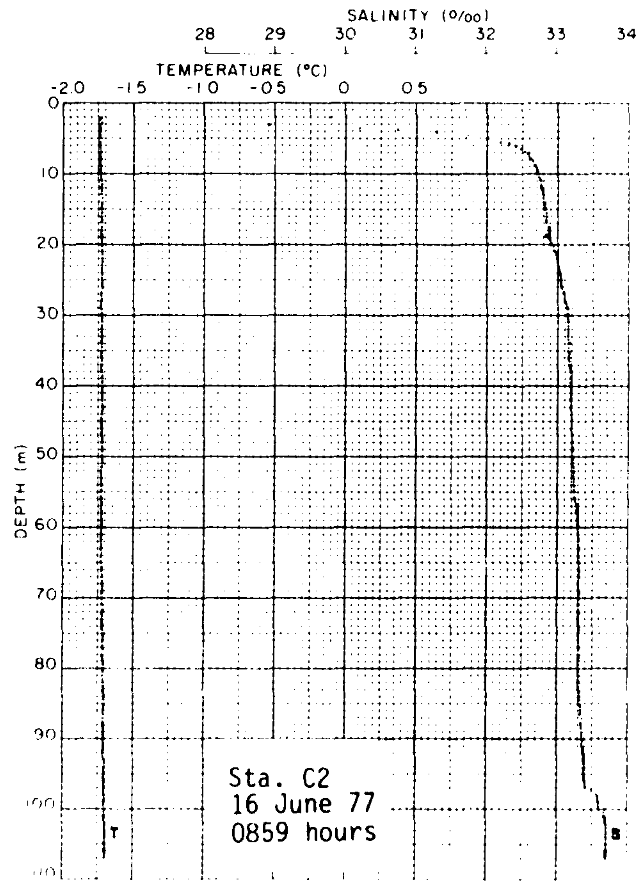

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-1.5 -1.0 -0.5 0 0.5
30 50 60
T
S
Sta. E11
13 June 77
1519 hours

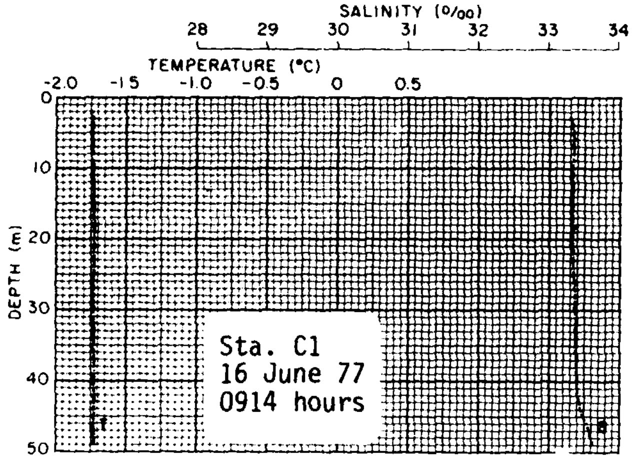

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2.0 -1.5 -1.0 -0.5 0 0.5
DEPTH (m)
0 10 20 30 40 50 60 70 80 90
24 25 26 27 28
DENSITY (σ_t)
Sta. C3
16 June 77
0730 hours

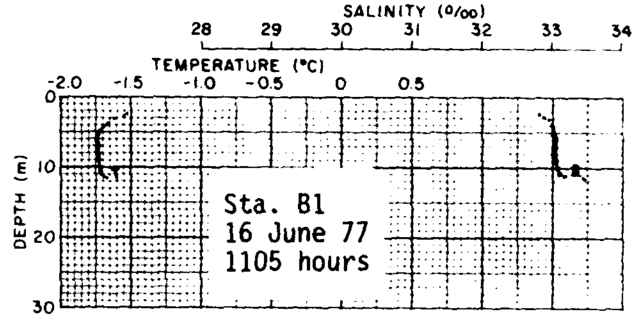

SALINITY (o/oo)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2.0 -1.5 -1.0 -0.5 0 0.5
DEPTH (m)
0 10 20 30 40 50 60 70 80 90
Sta. C4
16 June 77
0753 hours
T
S

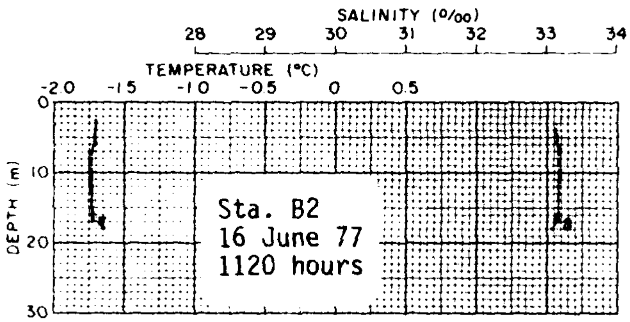

SALINITY (o/oo)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2.0 -1.5 -1.0 -0.5 0 0.5
DEPTH (m)
0 10 20 30 40 50 60 70 80 90
Sta. C5
16 June 77
0811 hours
T
S

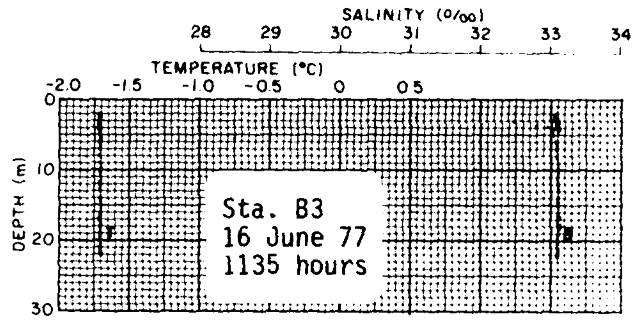

SALINITY (o/oo)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2.0 -1.5 -1.0 -0.5 0 0.5
DEPTH
0 10 20 30 40 50 60 70
Sta. C6
16 June 77
0828 hours

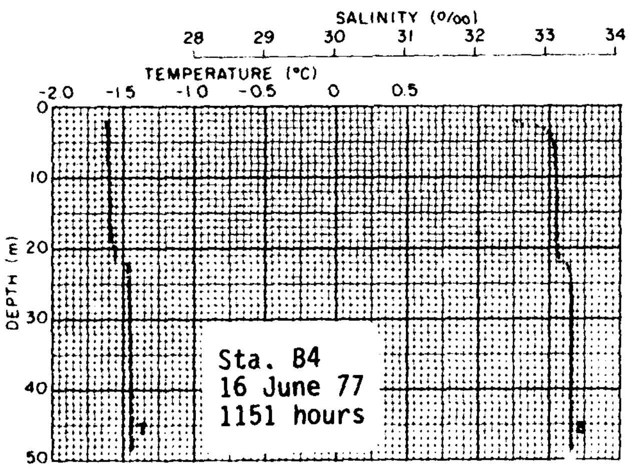

SALINITY (o/oo)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2.0 -1.5 -1.0 -0.5 0 0.5
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100
Sta. C2
16 June 77
0859 hours
T
S

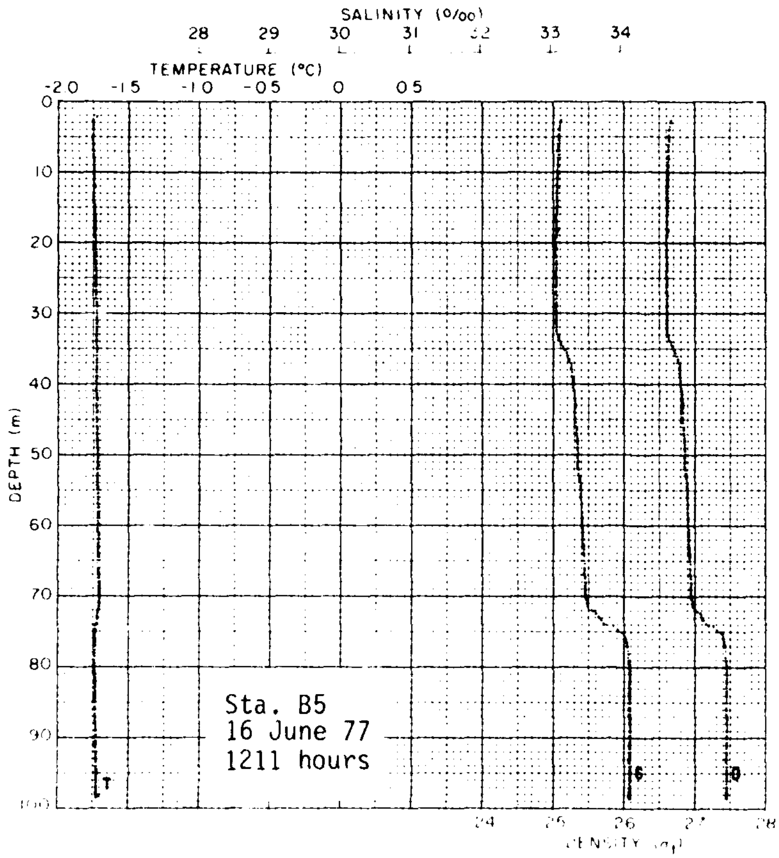

SALINITY (0/00)
TEMPERATURE (°C)
DEPTH (m)
Sta. C1
16 June 77
0914 hours


SALINITY (0/00)
TEMPERATURE (°C)
DEPTH (m)
Sta. B1
16 June 77
1105 hours

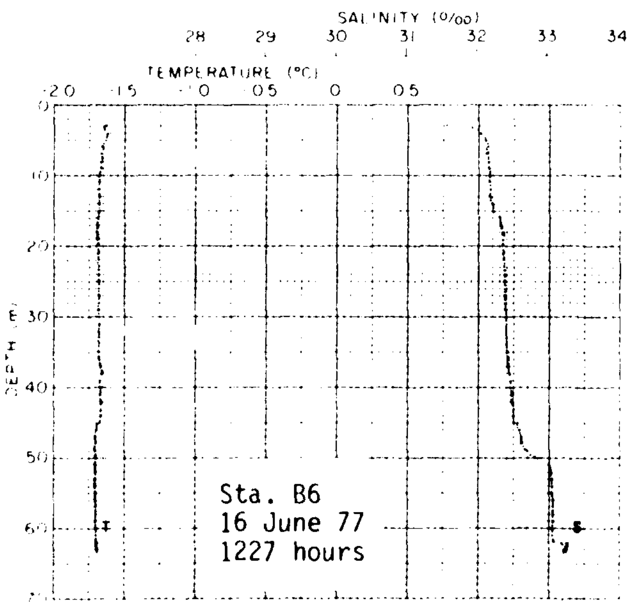

SALINITY (0/00)
TEMPERATURE (°C)
DEPTH (m)
Sta. B2
16 June 77
1120 hours


SALINITY (0/00)
TEMPERATURE (°C)
DEPTH (m)
Sta. B3
16 June 77
1135 hours

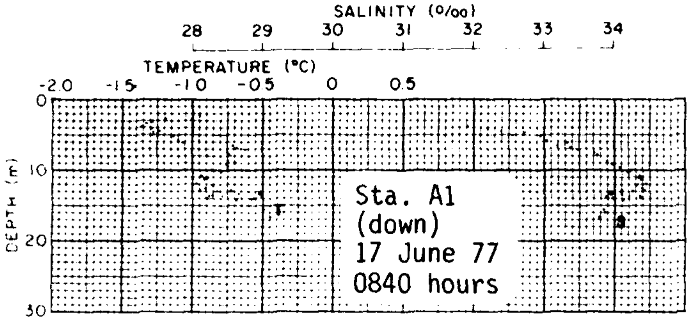

SALINITY (0/00)
TEMPERATURE (°C)
DEPTH (m)
Sta. B4
16 June 77
1151 hours

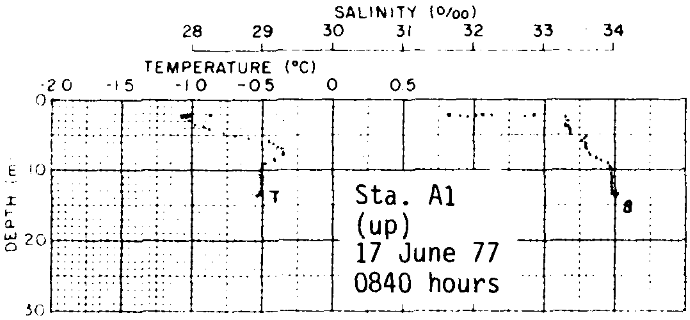


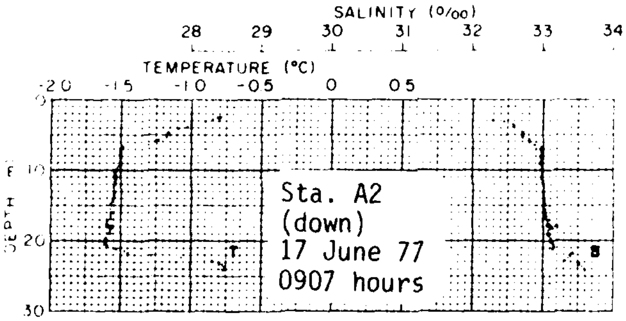
SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2.0 -1.5 -1.0 -0.5 0 0.5
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100
Sta. B5
16 June 77
1211 hours
T
G
D
24 25 26 27 28
DENSITY

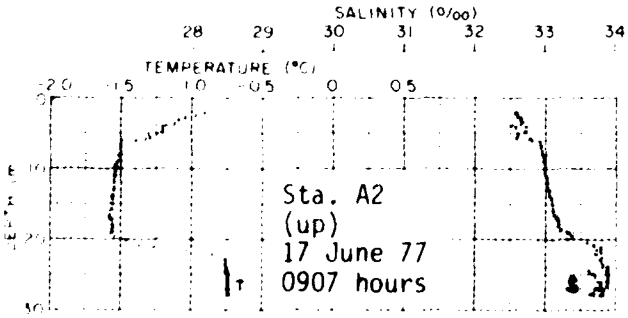


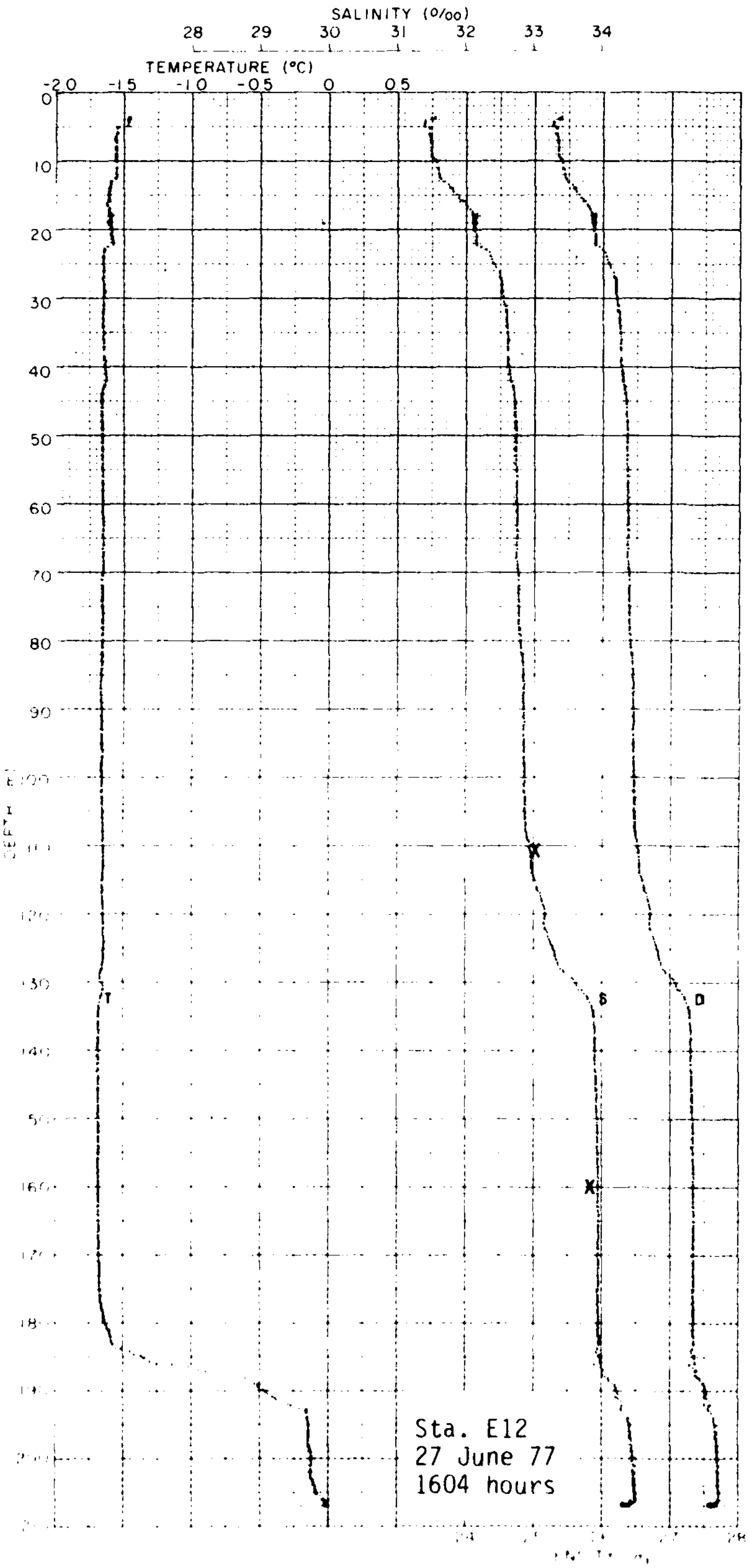
SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2.0 -1.5 -1.0 -0.5 0 0.5
DEPTH
0 10 20 30 40 50 60
Sta. B6
16 June 77
1227 hours
T
S


SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2.0 -1.5 -1.0 -0.5 0 0.5
DEPTH (m)
0 10 20 30
T
S
Sta. A1
(down)
17 June 77
0840 hours


SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2.0 -1.5 -1.0 -0.5 0 0.5
DEPTH (m)
0 10 20 30
T
S
Sta. A1
(up)
17 June 77
0840 hours


SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2.0 -1.5 -1.0 -0.5 0 0.5
DEPTH (m)
10 20 30
T
S
Sta. A2
(down)
17 June 77
0907 hours


SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
0 0.5
T
S
Sta. A2
(up)
17 June 77
0907 hours

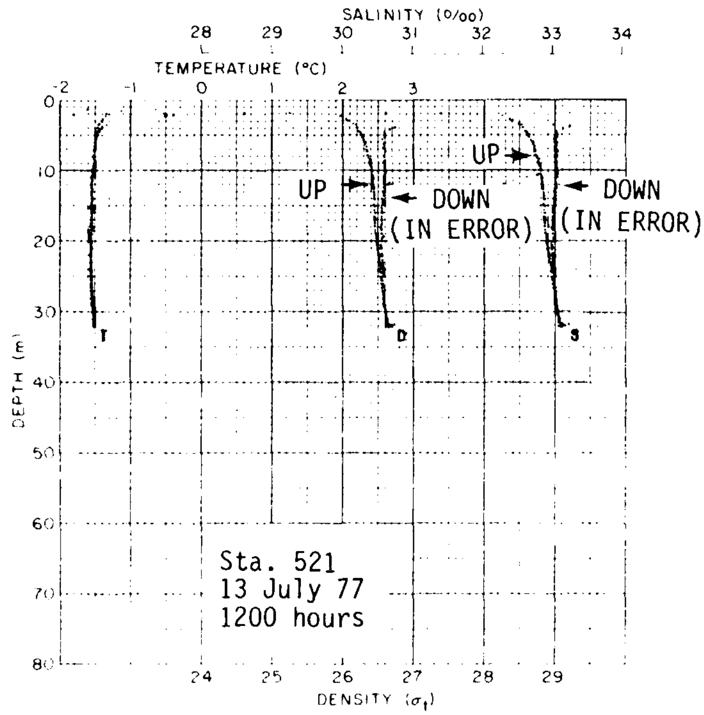

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2.0 -1.5 -1.0 -0.5 0 0.5
0 10 20 30 40 50 60 70 80 90
T
S
D
Sta. E12
27 June 77
1604 hours

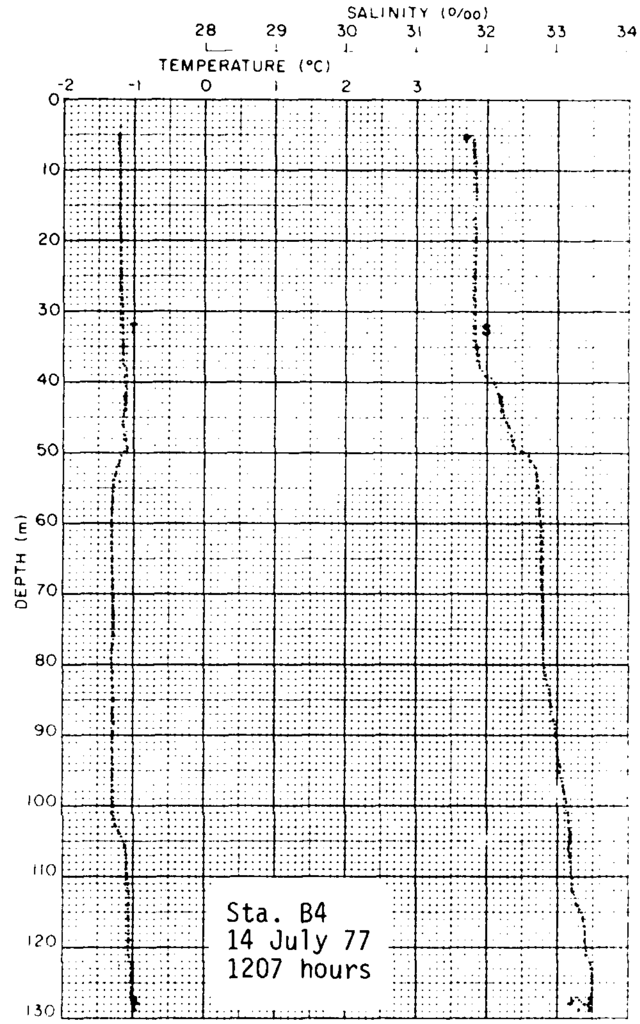
APPENDIX C

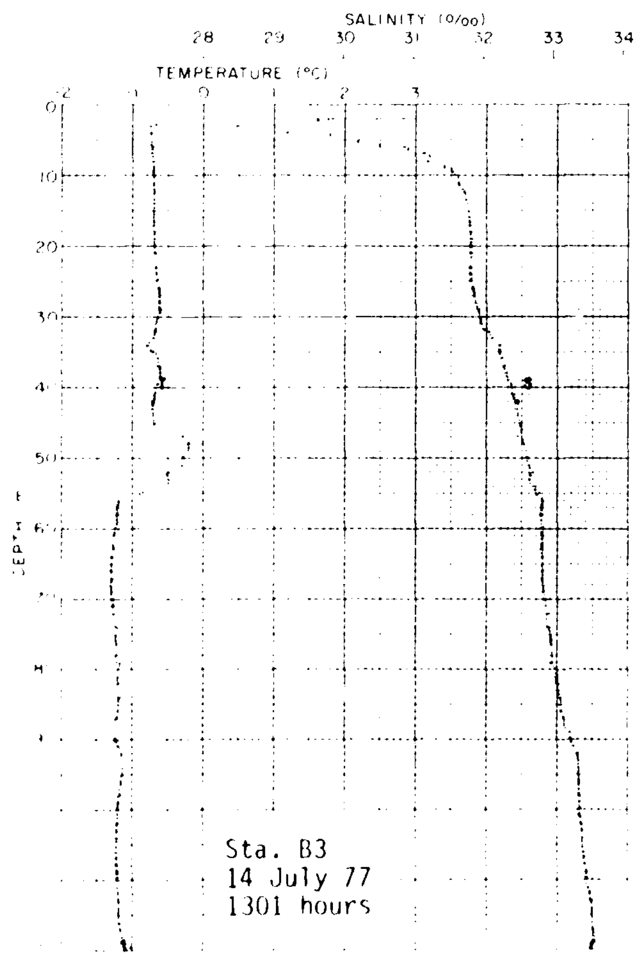
CHUKCHI SEA OCEANOGRAPHIC DATA OBTAINED
IN JULY 1977

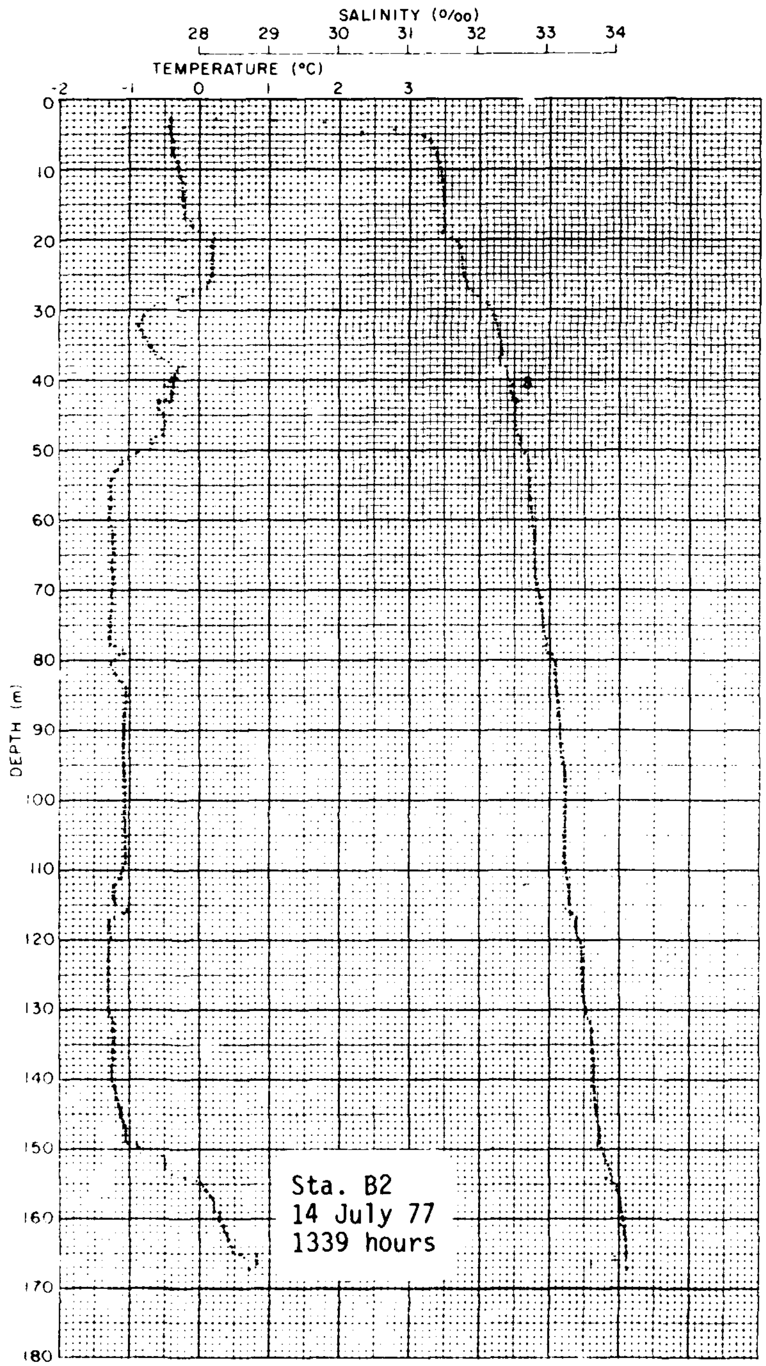
CTD profiles were again taken along several lines perpendicular to the coast. The locations of those stations for the July survey are shown in Figure 18, p. 25.

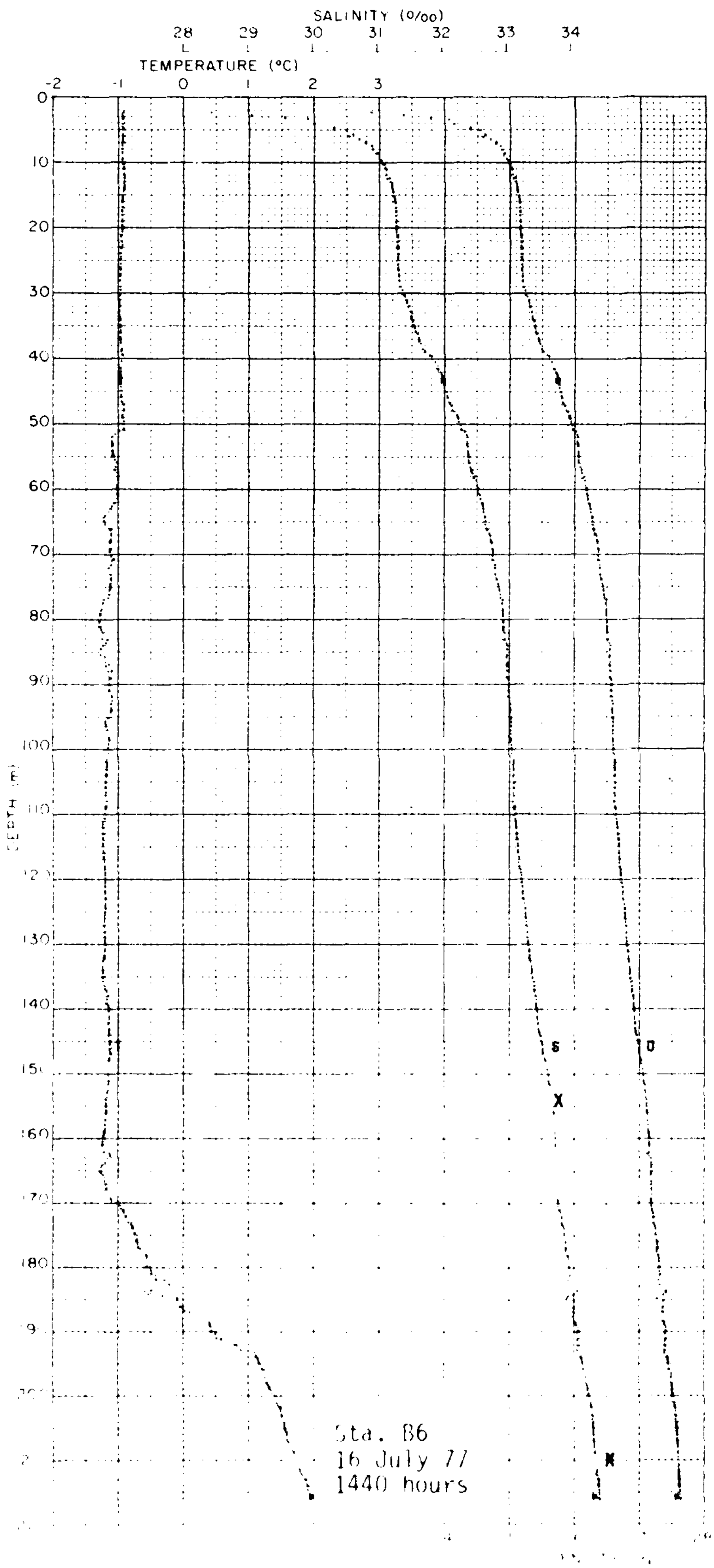
Station	Date	Local Time
521	13 July	1200
B4	14 July	1207
B3		1301
B2		1339
B6	16 July	1440
B5		1615
C6	17 July	1730
C5		1800
C3		1845

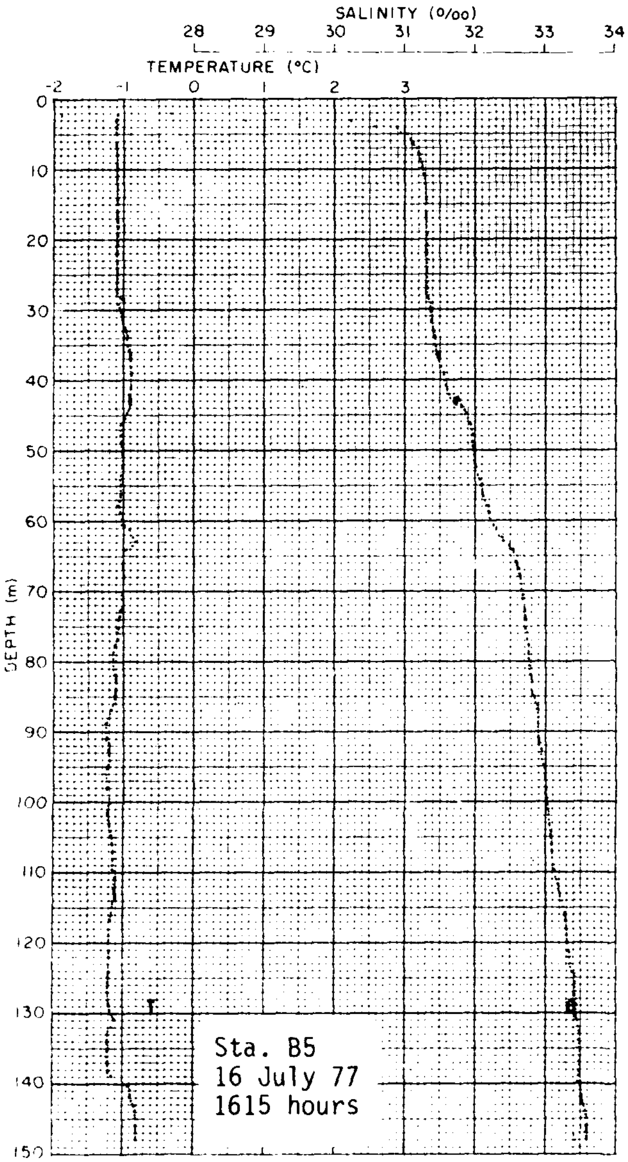

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
UP
DOWN
(IN ERROR)
UP
DOWN
(IN ERROR)
T
D
S
DEPTH (m)
0 10 20 30 40 50 60 70 80
Sta. 521
13 July 77
1200 hours
24 25 26 27 28 29
DENSITY (σ_t)

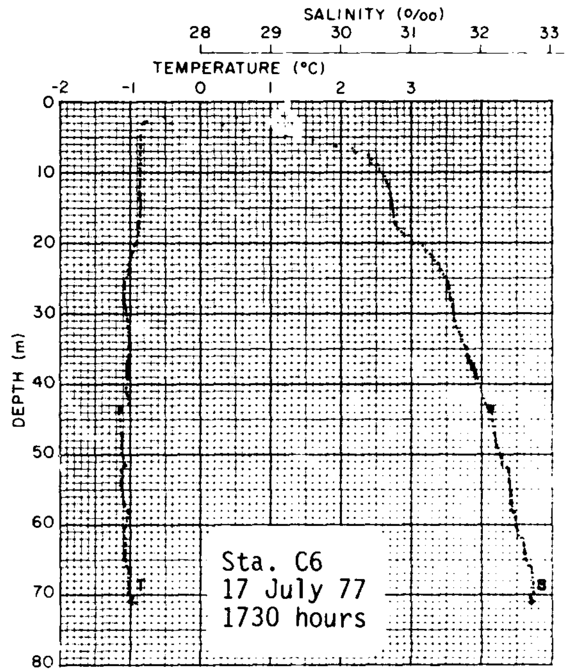

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130
S
Sta. B4
14 July 77
1207 hours

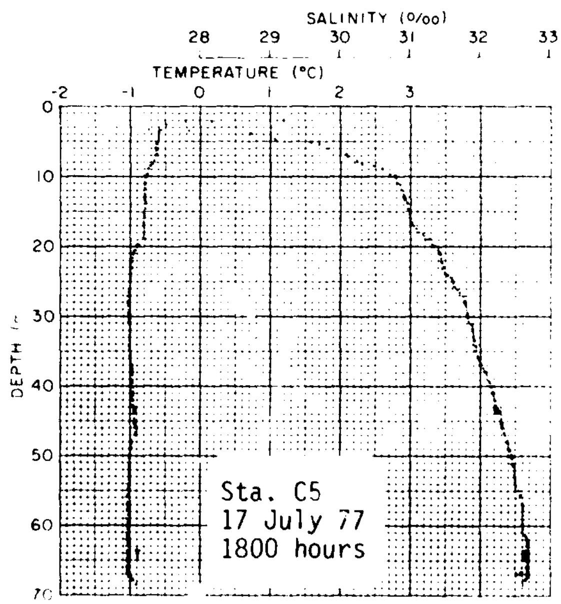

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
S
Sta. B3
14 July 77
1301 hours


SALINITY (0/oo)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
DEPTH (m)
Sta. B2
14 July 77
1339 hours


SALINITY (o/oo)
28
29
30
31
32
33
34
TEMPERATURE (°C)
-2
-1
0
1
2
3
0
10
20
30
40
50
60
70
80
90
100
DEPTH (m)
S
D
X
Sta. B6
16 July 77
1440 hours


SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
T
S
Sta. B5
16 July 77
1615 hours


SALINITY (0/00)
28 29 30 31 32 33
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80
T
S
Sta. C6
17 July 77
1730 hours

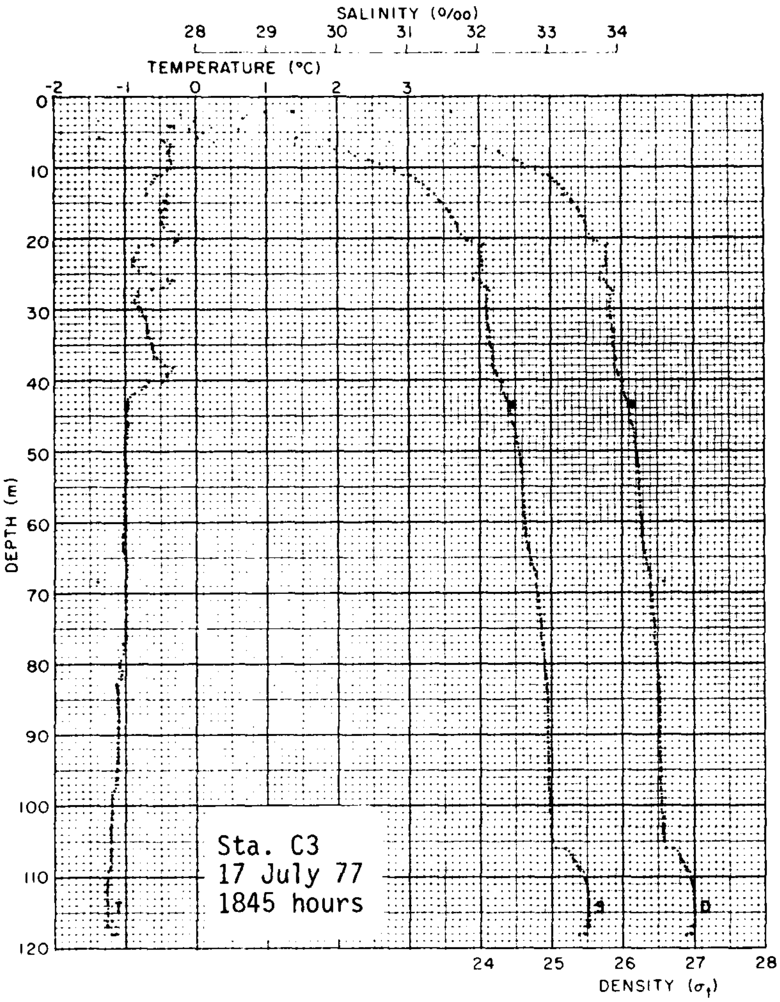

SALINITY (0/00)
28 29 30 31 32 33
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH
0 10 20 30 40 50 60 70
Sta. C5
17 July 77
1800 hours

AD-A088 841 WASHINGTON UNIV SEATTLE APPLIED PHYSICS LAB F/G 8/10
OCEANOGRAPHIC MEASUREMENTS IN THE CHUKCHI SEA, APRIL-AUGUST 197--ETC(U)
SEP 79 G R GARRISON, M L WELCH, J T SHAW N00123-74-C-2064
UNCLASSIFIED APL-UW-7824 NL

2 OF 3
AD A08884

END
FILMED
10-80
DTIC

Cont

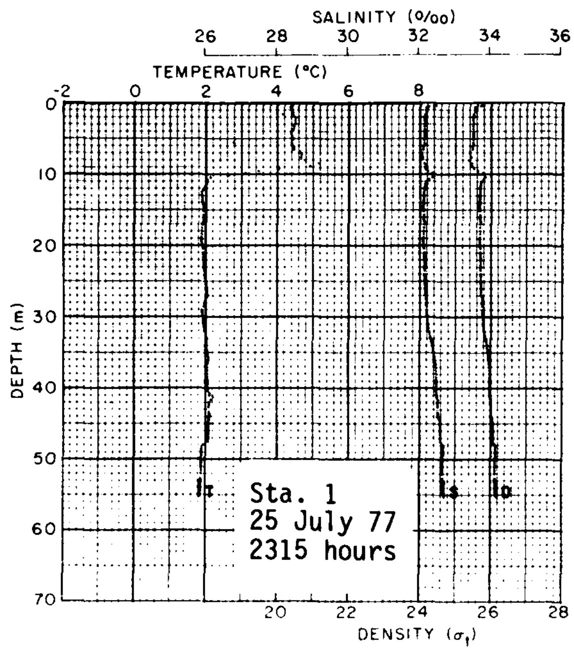

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120
Sta. C3
17 July 77
1845 hours
24 25 26 27 28
DENSITY (σ_t)

APPENDIX D

OCEANOGRAPHIC DATA FROM THE CRUISE OF THE
USCGC BURTON ISLAND TO THE CHUKCHI SEA
JULY-AUGUST 1977

The locations of the stations are shown in Figure 23, p. 33.

Station	Date	Local Time
1	25 July	2315
2	26 July	0327
3		0705
6		1218
14		2345
16	27 July	0710
18		1218
19		1510
20		1700
22		2112
23		2320
24	28 July	0202
25		0310
26		0445
27		0545
28		0637
30		1107
33		1430
34		1630
35		1849
36		1945
38		2210
39		2329
40	29 July	0140
41		0320
42		0436
43		0519
44		0638
45		0737
47		1300
48		1420
49		1520
51		1715
54		2140
56		2350
58	30 July	0144
59		0302
60		0438
130	3 Aug.	0810
131		1115
132		1455
133		1825
135		2120
136		2255
137	4 Aug.	0030
138		0225
139		0421
140		0539
141		0634
144		1038
145		1215
146		1313
147		1949
148		2055
149		2158
150		2310
151	5 Aug.	0139
152		0248
154		0600
155		0622
156		0730
157		0854


SALINITY (o/oo)
26 28 30 32 34 36
TEMPERATURE (°C)
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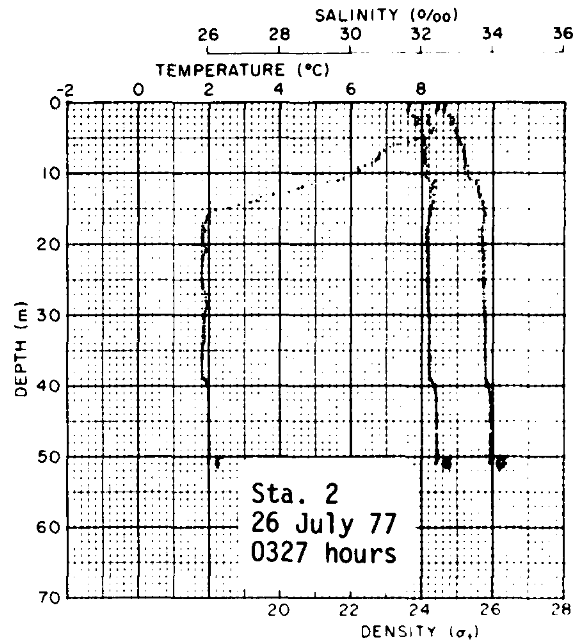
DEPTH (m)
0 10 20 30 40 50 60 70
DENSITY (σ_t)
20 22 24 26 28
Sta. 1
25 July 77
2315 hours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TEMPERATURE (°C)
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DEPTH (m)
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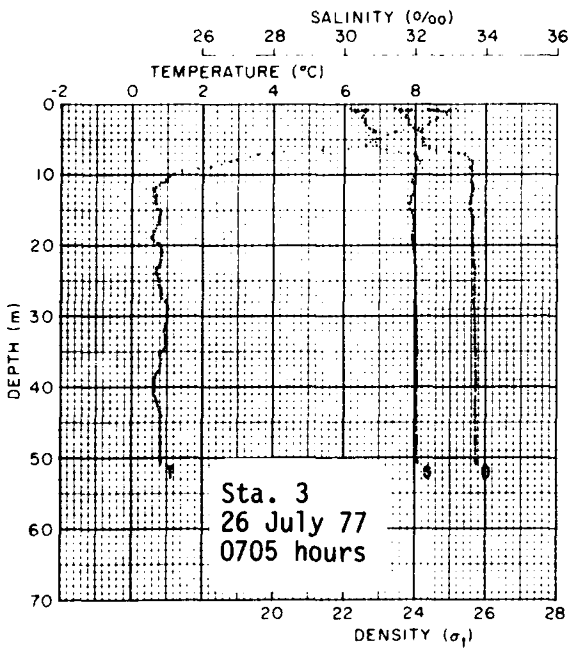
DENSITY (σ_t)
20 22 24 26 28
Sta. 2
26 July 77
0327 hours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TEMPERATURE (°C)
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DEPTH (m)
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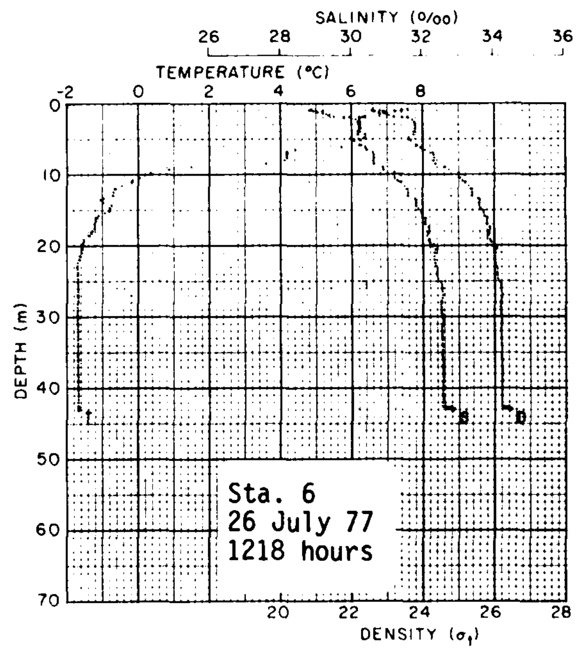
DENSITY (σ_t)
20 22 24 26 28
Sta. 3
26 July 77
0705 hours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TEMPERATURE (°C)
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DEPTH (m)
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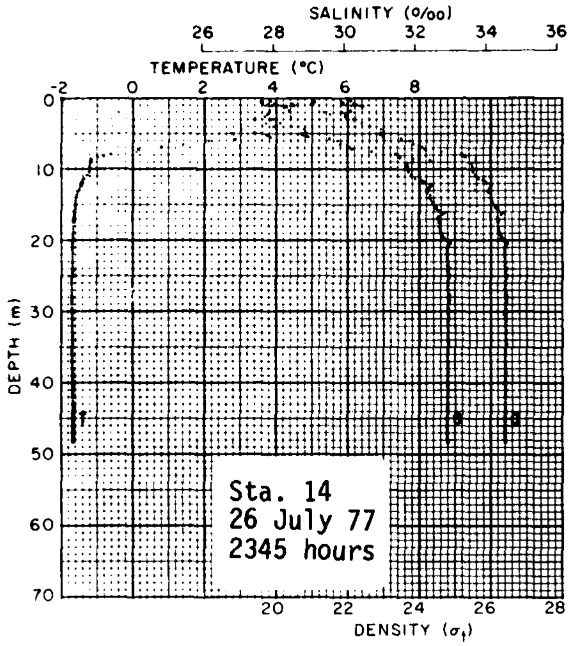
DENSITY (σ_t)
20 22 24 26 28
Sta. 6
26 July 77
1218 hours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TEMPERATURE (°C)
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DEPTH (m)
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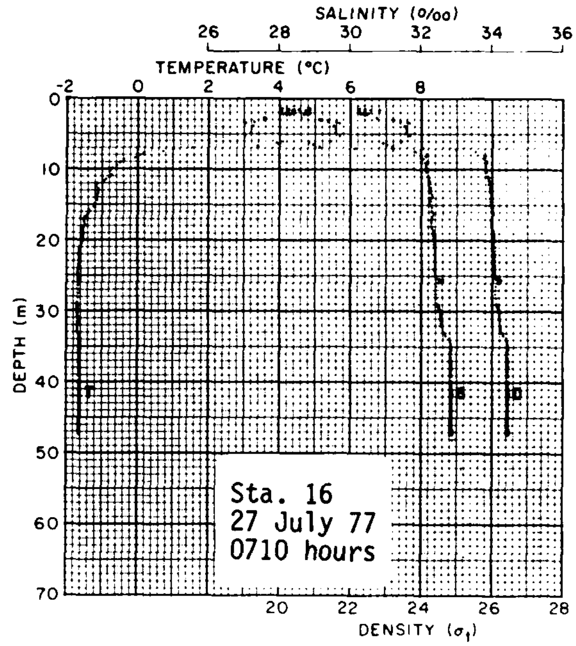
T
S
D
Sta. 14
26 July 77
2345 hours
20 22 24 26 28
DENSITY (σ_t)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26 28 30 32 34 36
TEMPERATURE (°C)
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DEPTH (m)
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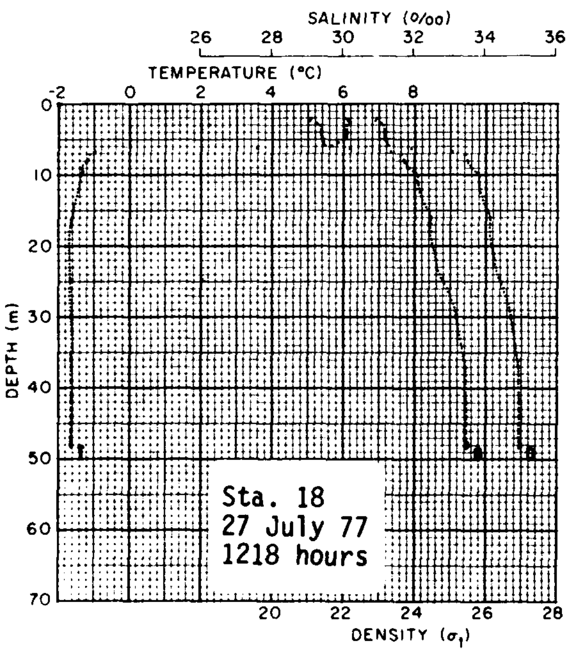
T
S
D
Sta. 16
27 July 77
0710 hours
20 22 24 26 28
DENSITY (σ_t)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TEMPERATURE (°C)
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DEPTH (m)
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T
S
D
Sta. 18
27 July 77
1218 hours
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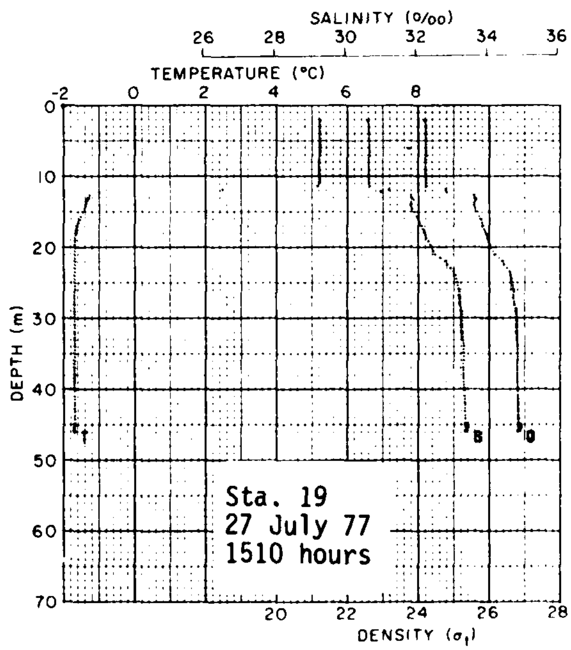
DENSITY (σ_t)


SALINITY (0/00)
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TEMPERATURE (°C)
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DEPTH (m)
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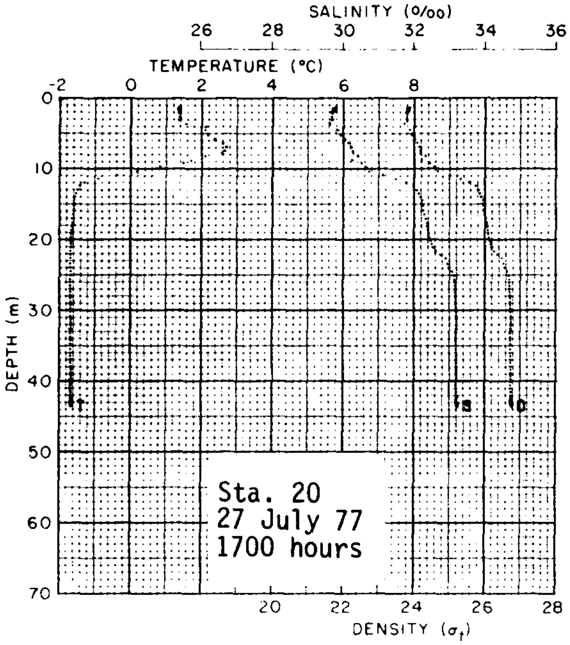
T
S
D
Sta. 19
27 July 77
1510 hours
20 22 24 26 28
DENSITY (σ_t)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TEMPERATURE (°C)
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DEPTH (m)
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T S D
Sta. 20
27 July 77
1700 hours
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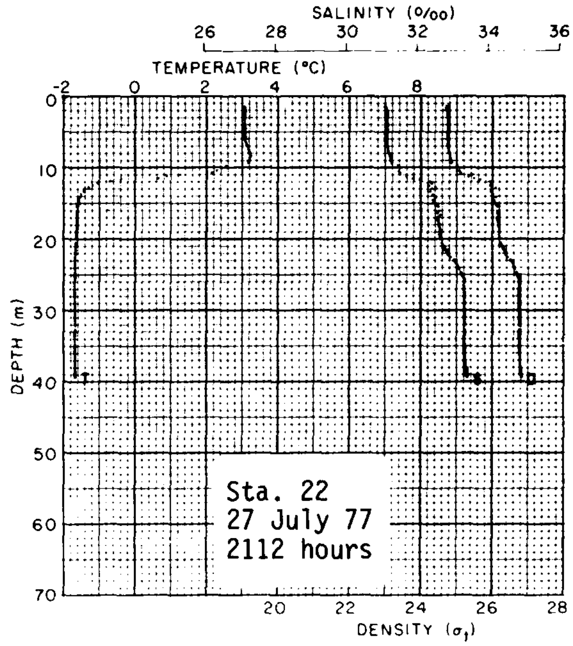
DENSITY (σ_t)


SALINITY (0/00)
26 28 30 32 34 36
TEMPERATURE (°C)
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DEPTH (m)
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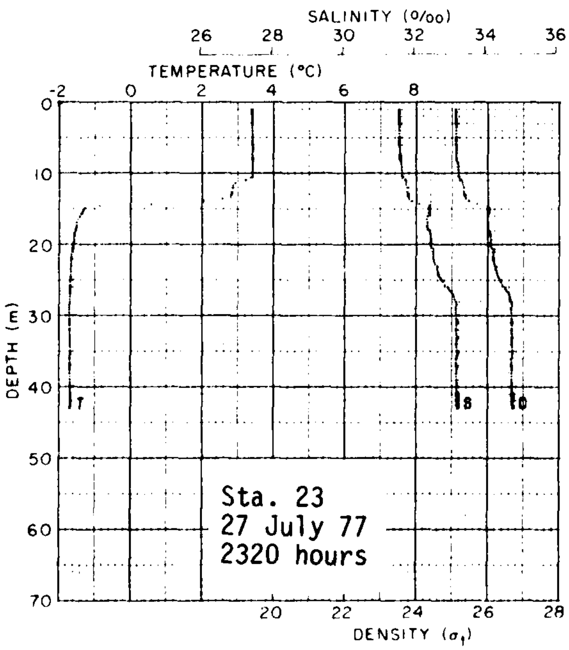
T S D
Sta. 22
27 July 77
2112 hours
20 22 24 26 28
DENSITY (σ_t)


SALINITY (0/00)
26 28 30 32 34 36
TEMPERATURE (°C)
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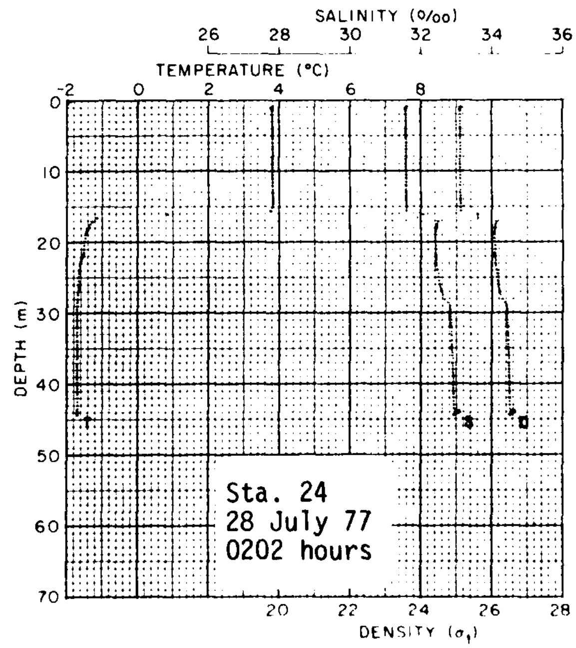
DEPTH (m)
0 10 20 30 40 50 60 70
T S D
Sta. 23
27 July 77
2320 hours
20 22 24 26 28
DENSITY (σ_t)


SALINITY (0/00)
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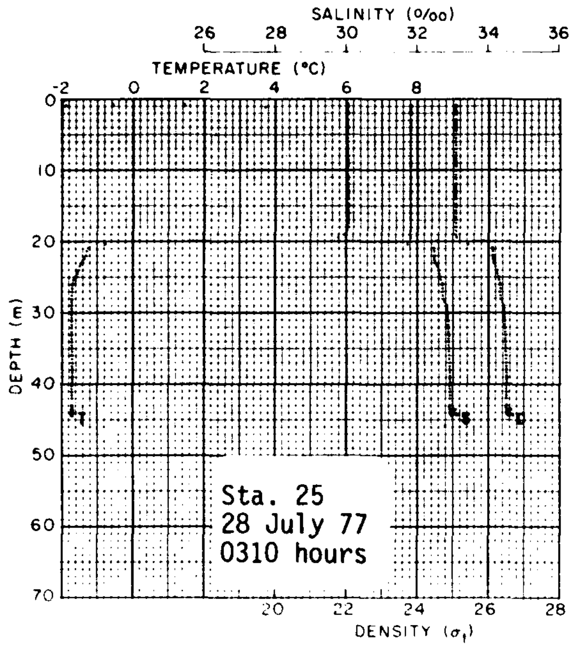
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
T S D
Sta. 24
28 July 77
0202 hours
20 22 24 26 28
DENSITY (σ_t)


SALINITY (0/00)
26 28 30 32 34 36
TEMPERATURE (°C)
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DEPTH (m)
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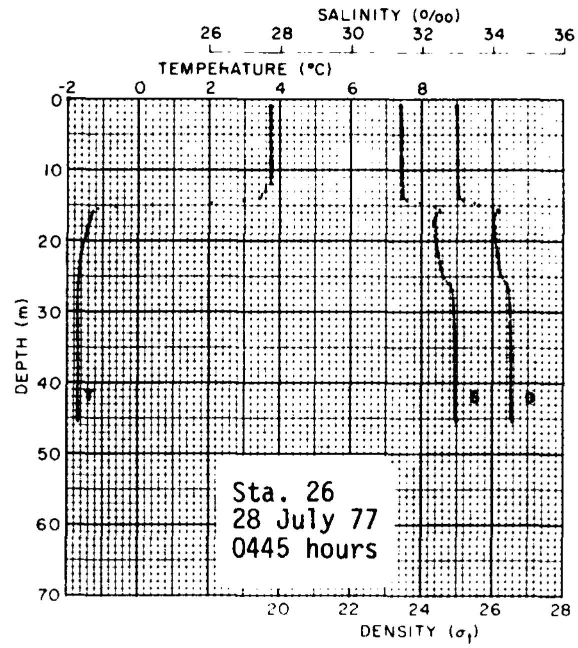
T S D
Sta. 25
28 July 77
0310 hours
20 22 24 26 28
DENSITY (σ_t)


SALINITY (0/00)
26 28 30 32 34 36
TEMPERATURE (°C)
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DEPTH (m)
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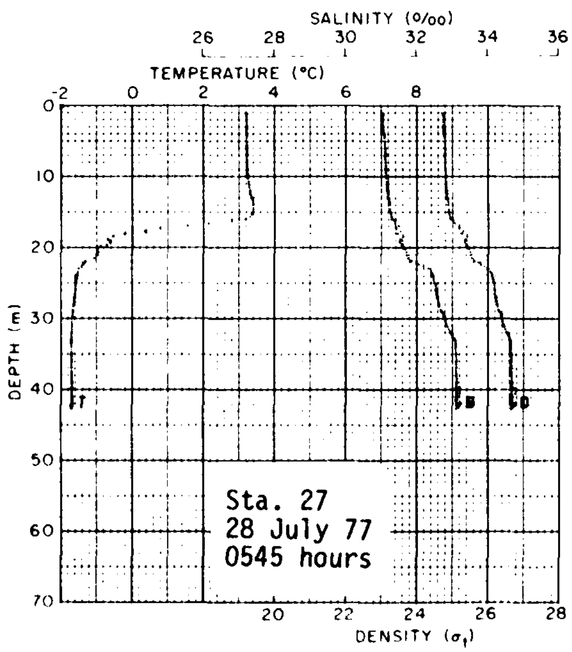
T S D
Sta. 26
28 July 77
0445 hours
20 22 24 26 28
DENSITY (σ_t)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TEMPERATURE (°C)
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DEPTH (m)
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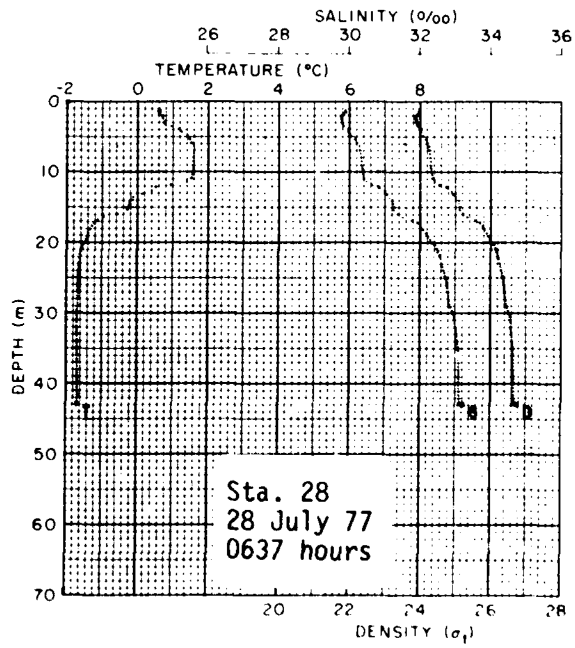
T S D
Sta. 27
28 July 77
0545 hours
20 22 24 26 28
DENSITY (σ_t)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26 28 30 32 34 36
TEMPERATURE (°C)
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DEPTH (m)
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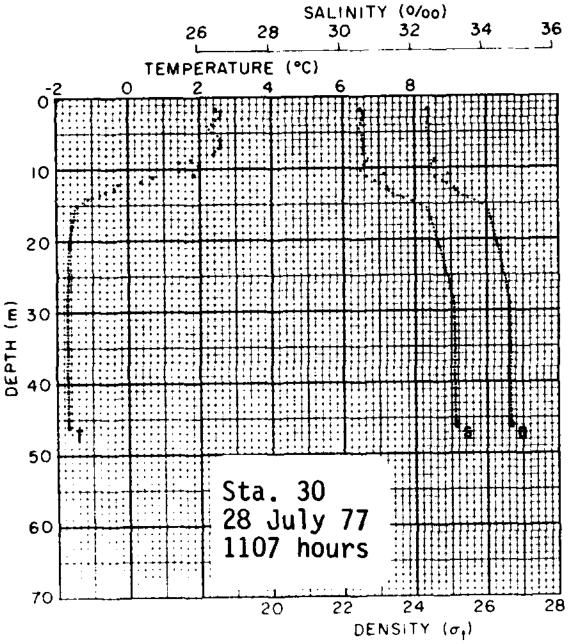
T S D
Sta. 28
28 July 77
0637 hours
20 22 24 26 28
DENSITY (σ_t)


SALINITY (0/oo)
26 28 30 32 34 36
TEMPERATURE (°C)
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DEPTH (m)
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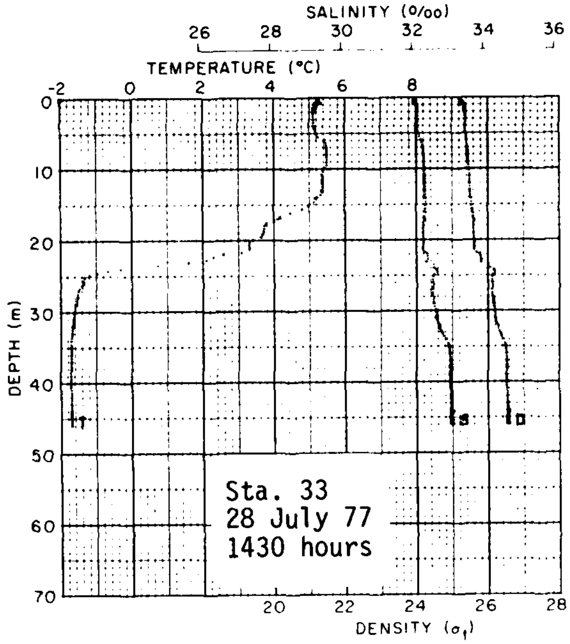
DENSITY (σt)
20 22 24 26 28
Sta. 30
28 July 77
1107 hours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26 28 30 32 34 36
TEMPERATURE (°C)
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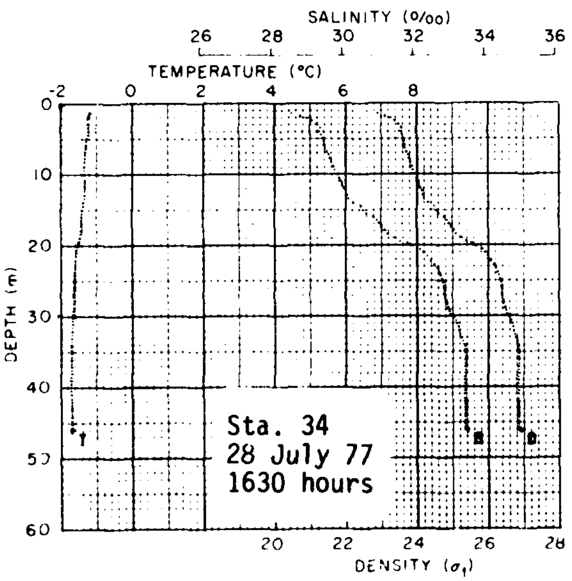
DEPTH (m)
0 10 20 30 40 50 60 70
DENSITY (σt)
20 22 24 26 28
Sta. 33
28 July 77
1430 hours


SALINITY (0/oo)
26 28 30 32 34 36
TEMPERATURE (°C)
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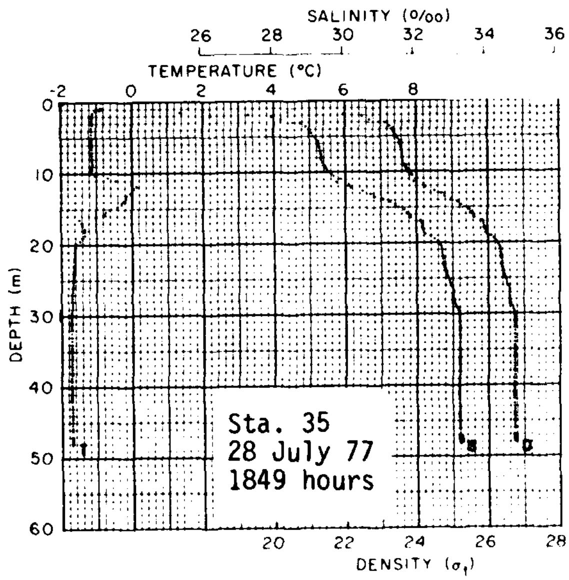
DEPTH (m)
0 10 20 30 40 50 60
DENSITY (σt)
20 22 24 26 28
Sta. 34
28 July 77
1630 hours


SALINITY (0/oo)
26 28 30 32 34 36
TEMPERATURE (°C)
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DEPTH (m)
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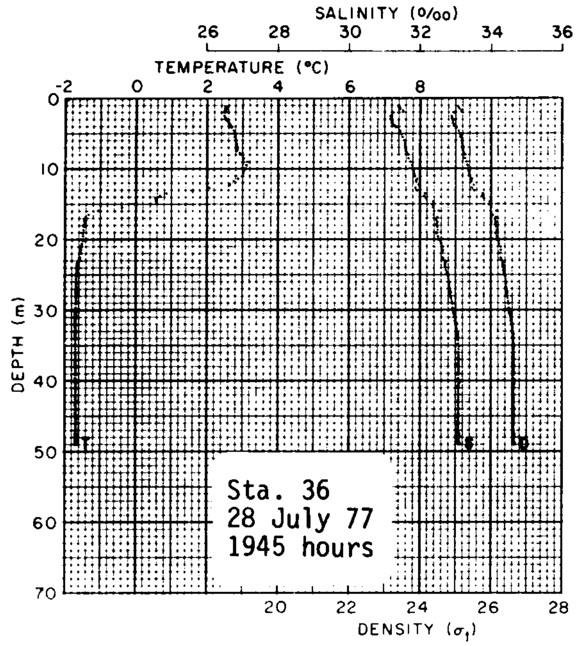
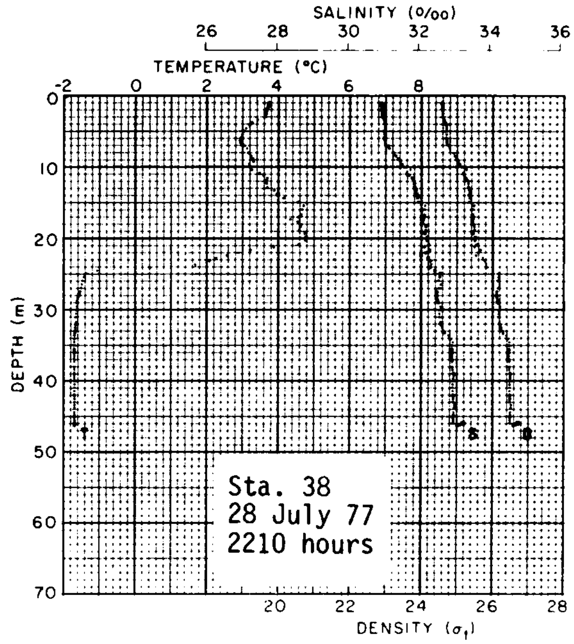
DENSITY (σt)
20 22 24 26 28
Sta. 35
28 July 77
1849 hours


SALINITY (0/00)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
T
S
D
Sta. 36
28 July 77
1945 hours
20 22 24 26 28
DENSITY (σ_t)


SALINITY (0/00)
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TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
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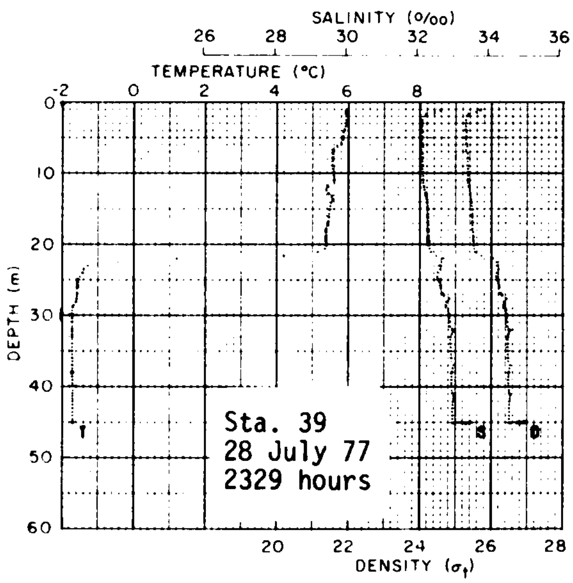
T
S
D
Sta. 38
28 July 77
2210 hours
20 22 24 26 28
DENSITY (σ_t)


SALINITY (0/00)
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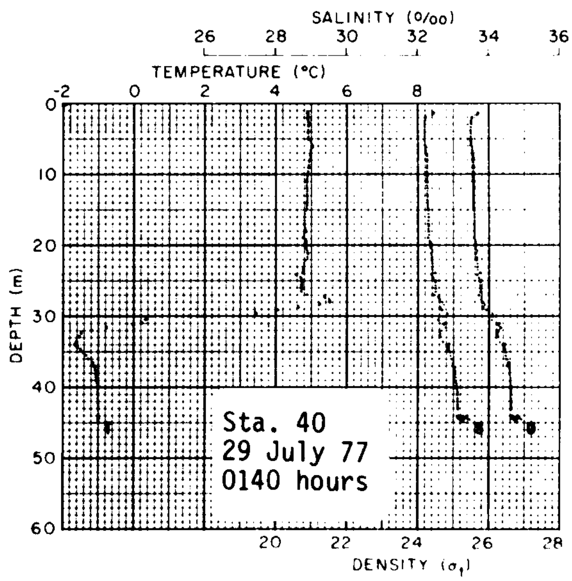
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60
T
S
D
Sta. 39
28 July 77
2329 hours
20 22 24 26 28
DENSITY (σ_t)


SALINITY (0/00)
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TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
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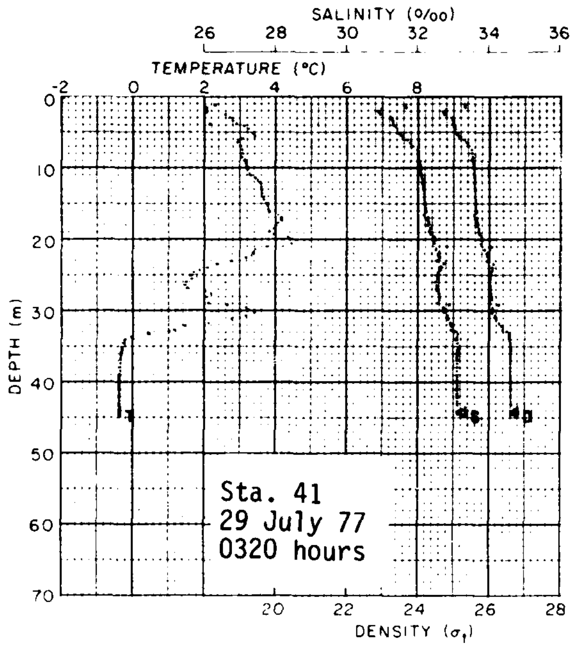
T
S
D
Sta. 40
29 July 77
0140 hours
20 22 24 26 28
DENSITY (σ_t)


SALINITY (0/00)
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TEMPERATURE (°C)
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DEPTH (m)
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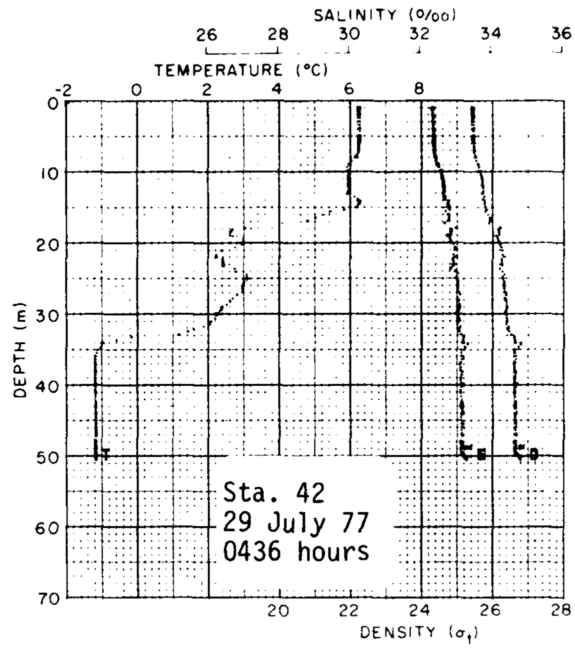
DENSITY (σ_t)
Sta. 41
29 July 77
0320 hours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TEMPERATURE (°C)
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DEPTH (m)
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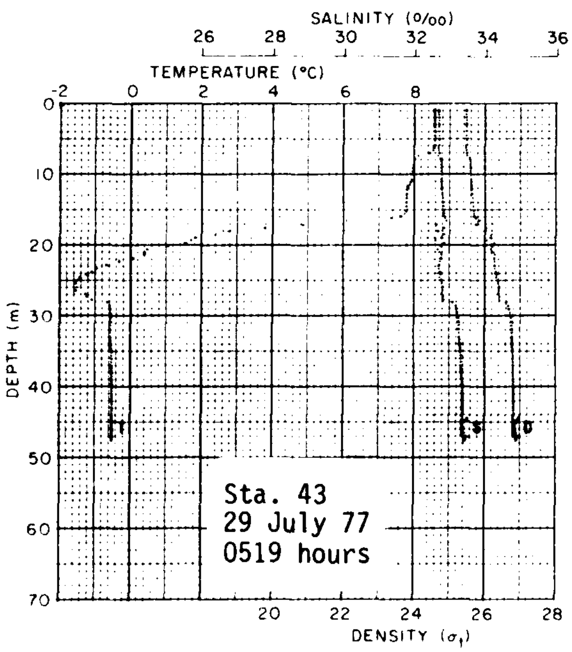
DENSITY (σ_t)
Sta. 42
29 July 77
0436 hours


SALINITY (0/00)
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TEMPERATURE (°C)
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DEPTH (m)
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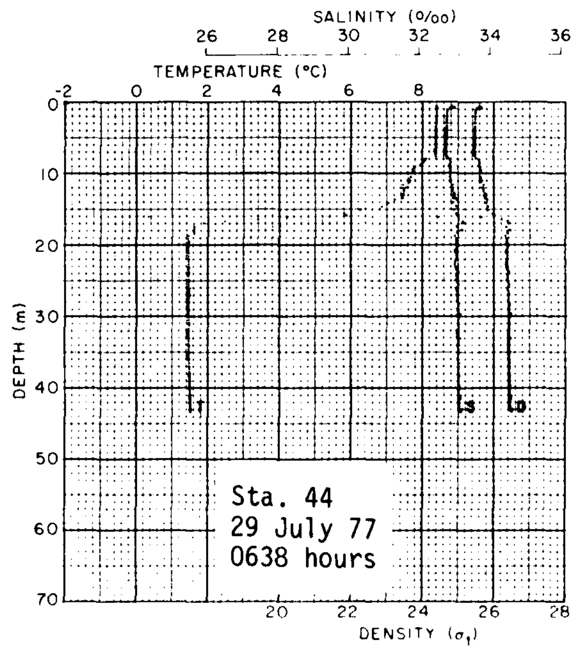
20 22 24 26 28
DENSITY (σ_t)
Sta. 43
29 July 77
0519 hours


SALINITY (0/00)
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TEMPERATURE (°C)
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DEPTH (m)
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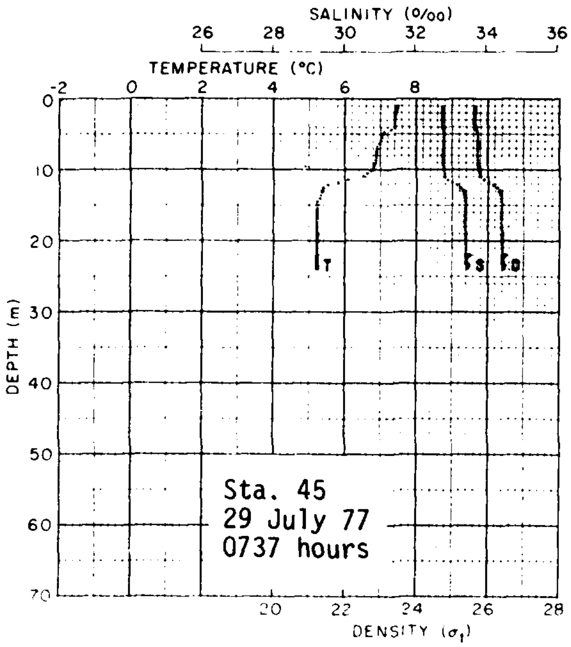
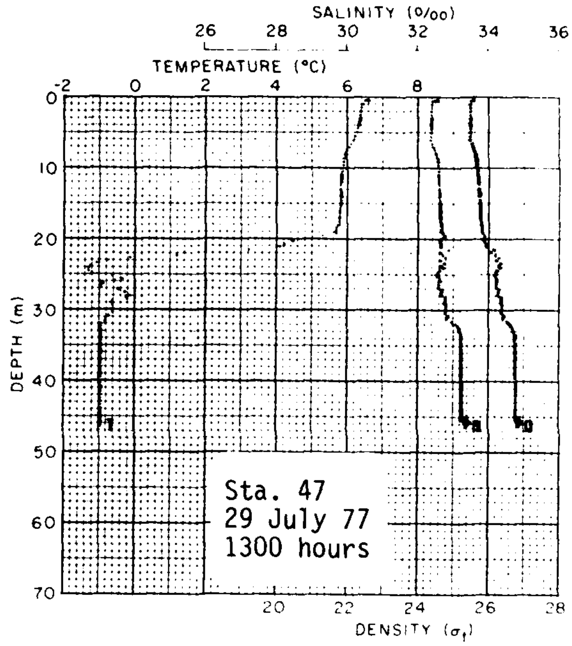
20 22 24 26 28
DENSITY (σ_t)
Sta. 44
29 July 77
0638 hours


SALINITY (0/00)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
T S D
Sta. 45
29 July 77
0737 hours
20 22 24 26 28
DENSITY (σ_t)


SALINITY (0/00)
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TEMPERATURE (°C)
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DEPTH (m)
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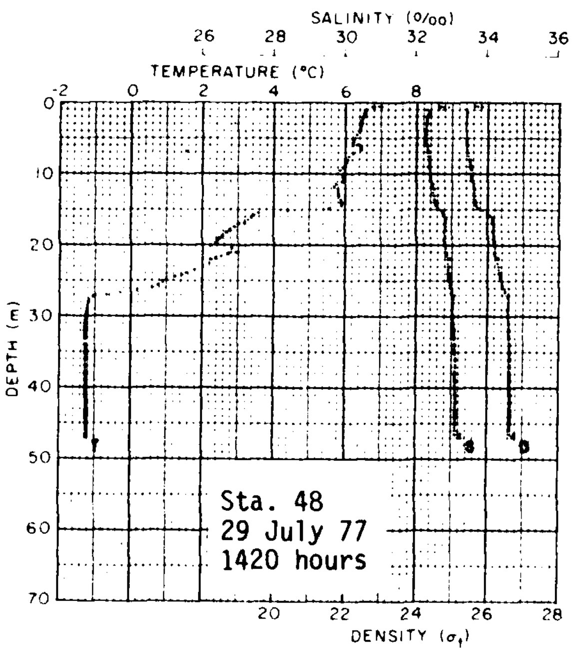
Sta. 47
29 July 77
1300 hours
20 22 24 26 28
DENSITY (σ_t)


SALINITY (0/00)
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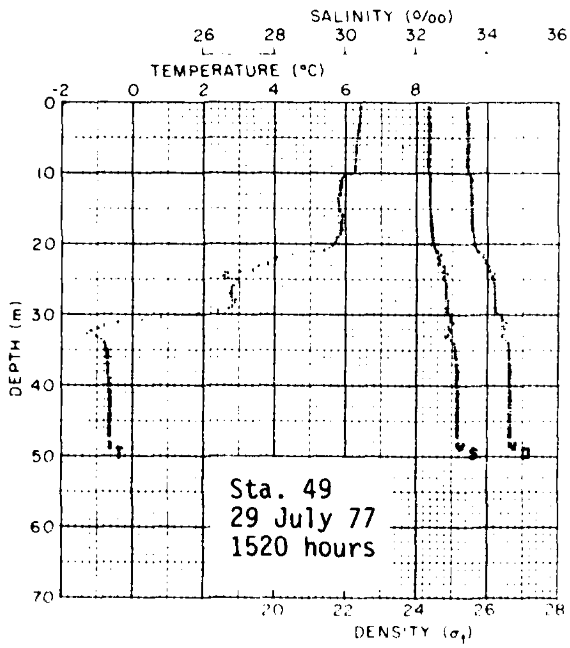
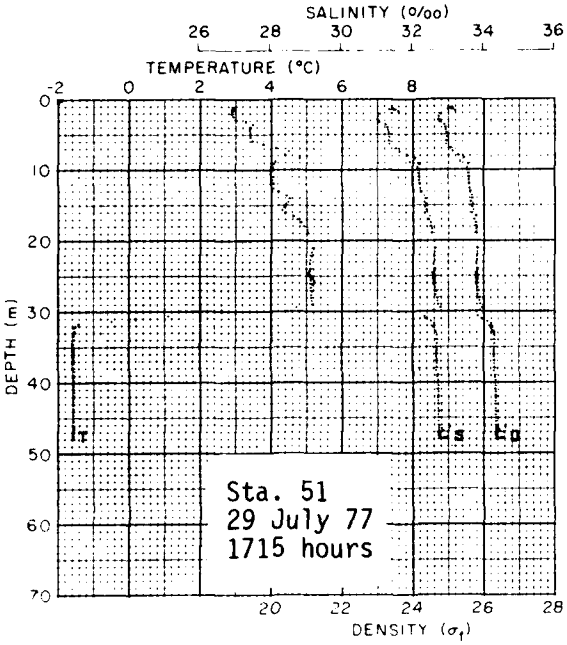
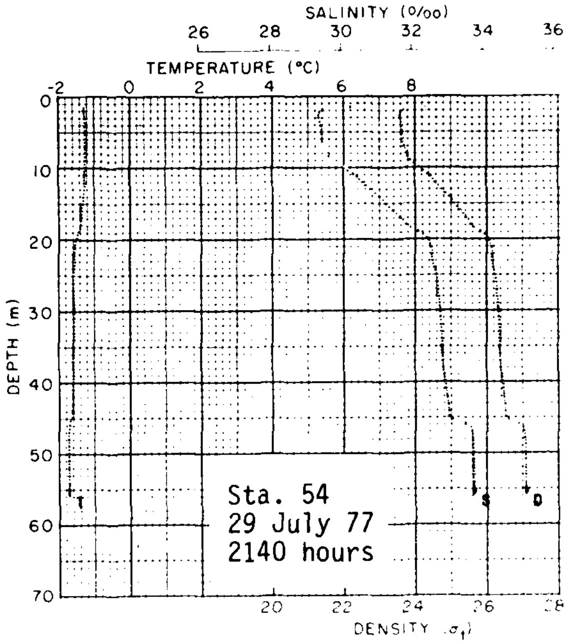
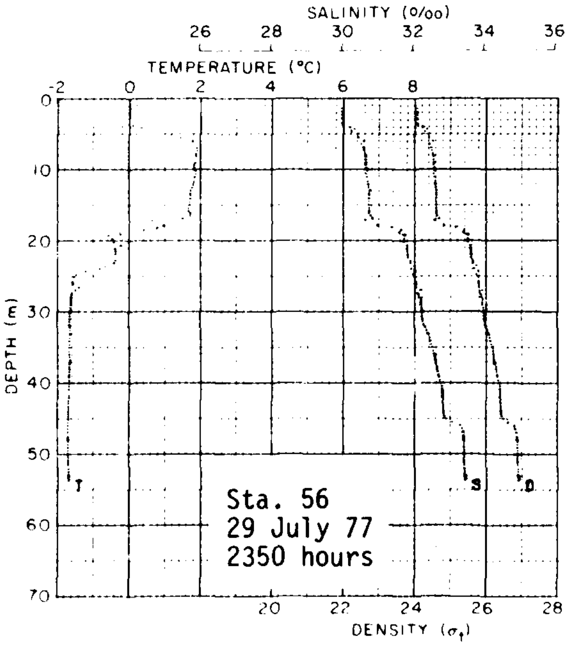
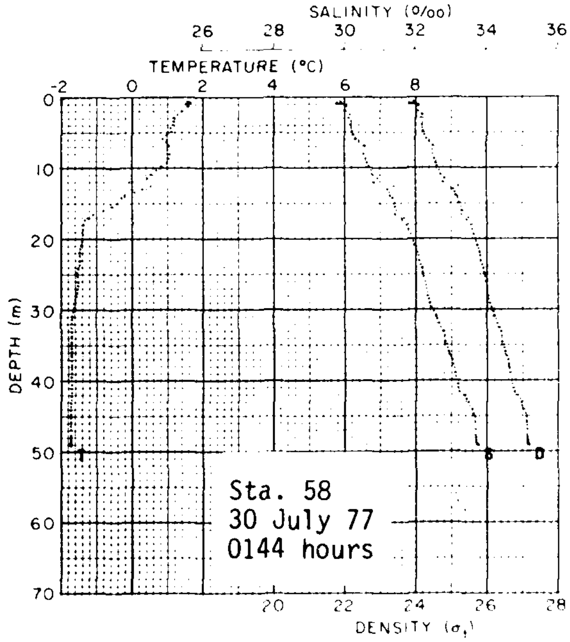
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
T S D
Sta. 48
29 July 77
1420 hours
20 22 24 26 28
DENSITY (σ_t)

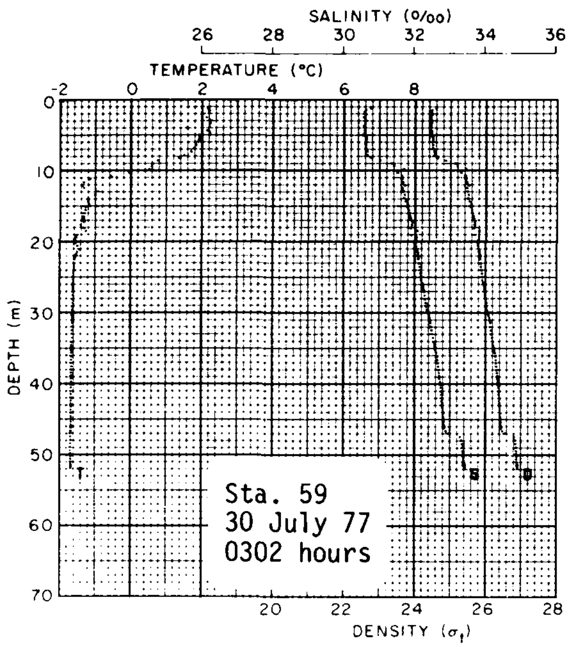

SALINITY (0/00)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
T S D
Sta. 49
29 July 77
1520 hours
20 22 24 26 28
DENSITY (σ_t)

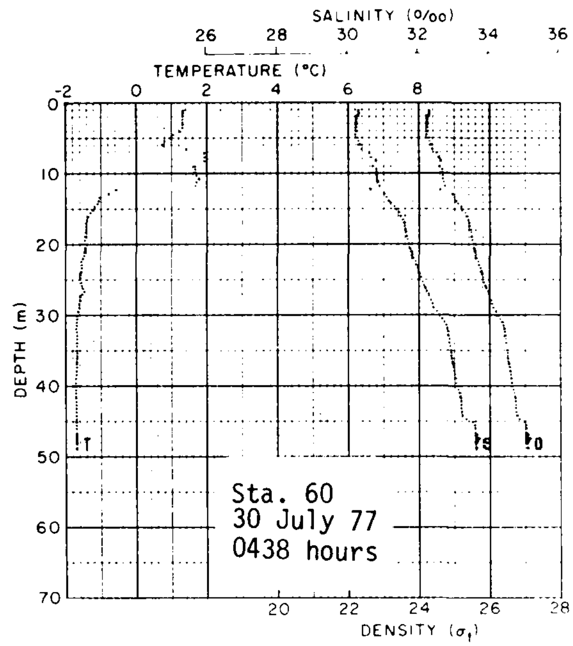

SALINITY (0/oo)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
DENSITY (σ_t)
20 22 24 26 28
T S D
Sta. 51
29 July 77
1715 hours

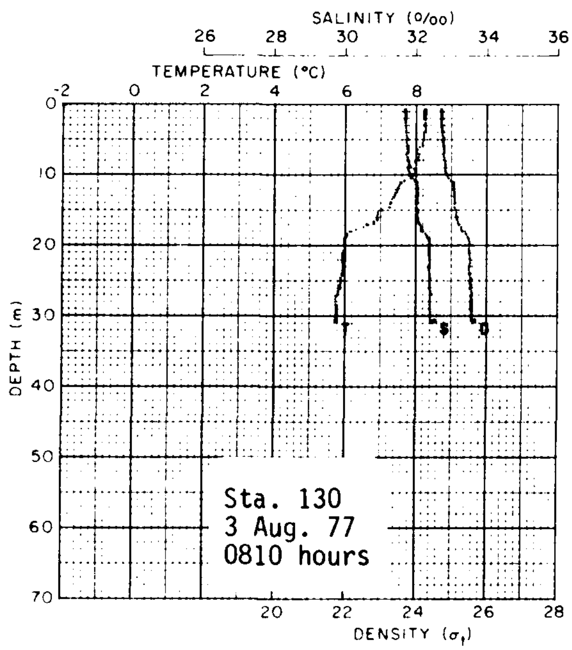

SALINITY (0/oo)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
DENSITY (σ_t)
20 22 24 26 28
T S D
Sta. 54
29 July 77
2140 hours

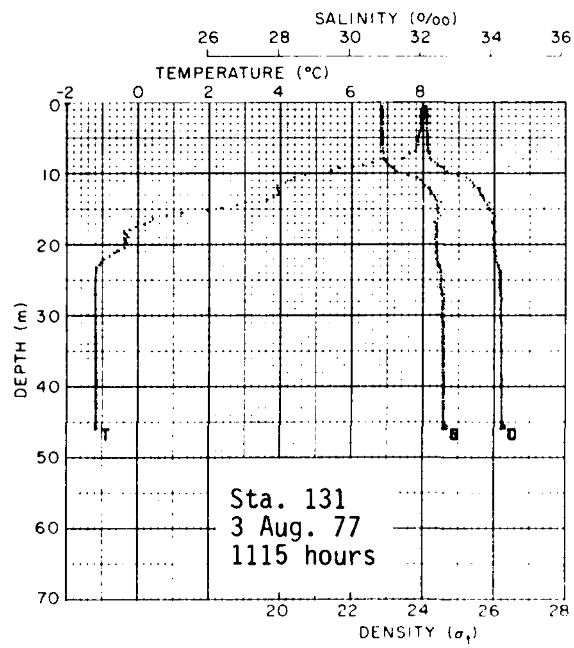

SALINITY (0/oo)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
DENSITY (σ_t)
20 22 24 26 28
T S D
Sta. 56
29 July 77
2350 hours

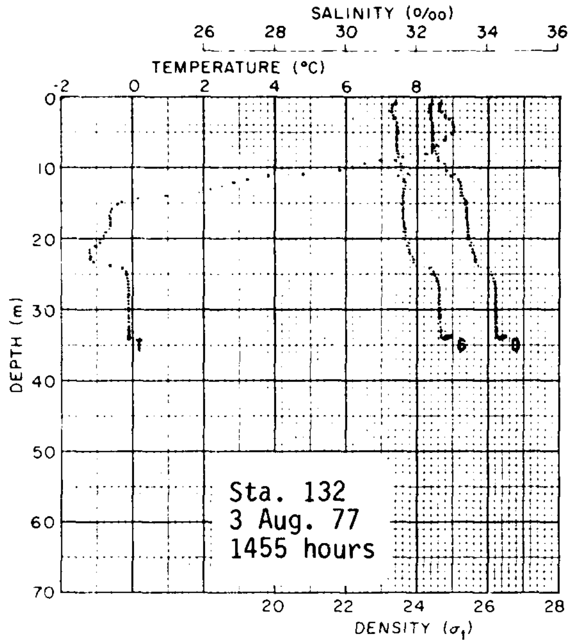

SALINITY (0/oo)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
DENSITY (σ_t)
20 22 24 26 28
T S D
Sta. 58
30 July 77
0144 hours


SALINITY (0/oo)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
T
S
D
Sta. 59
30 July 77
0302 hours
20 22 24 26 28
DENSITY (σ_t)


SALINITY (0/oo)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
T
S
D
Sta. 60
30 July 77
0438 hours
20 22 24 26 28
DENSITY (σ_t)


SALINITY (0/oo)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
T
S
D
Sta. 130
3 Aug. 77
0810 hours
20 22 24 26 28
DENSITY (σ_t)


SALINITY (0/oo)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
T
S
D
Sta. 131
3 Aug. 77
1115 hours
20 22 24 26 28
DENSITY (σ_t)


SALINITY (o/oo)
26 28 30 32 34 36
TEMPERATURE (°C)
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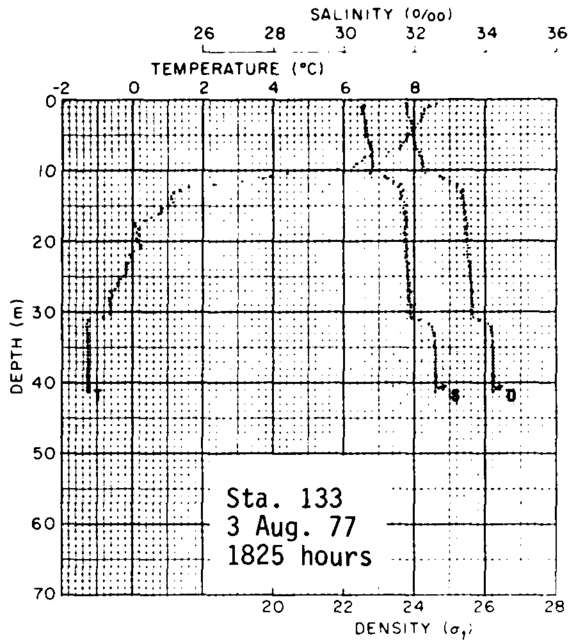
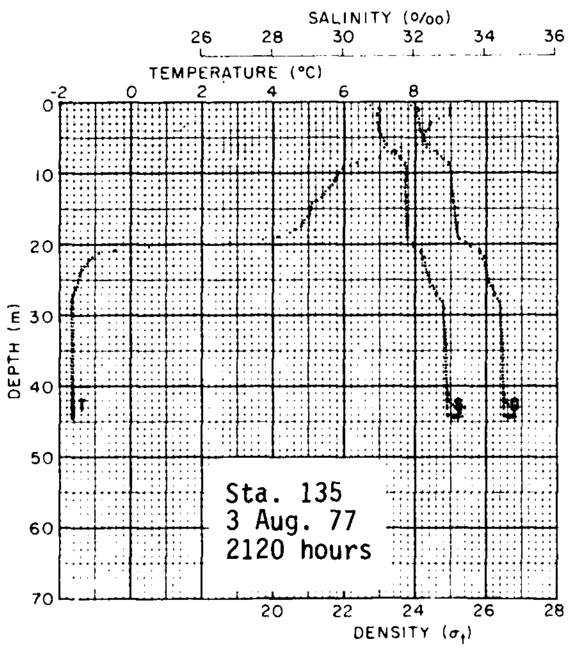
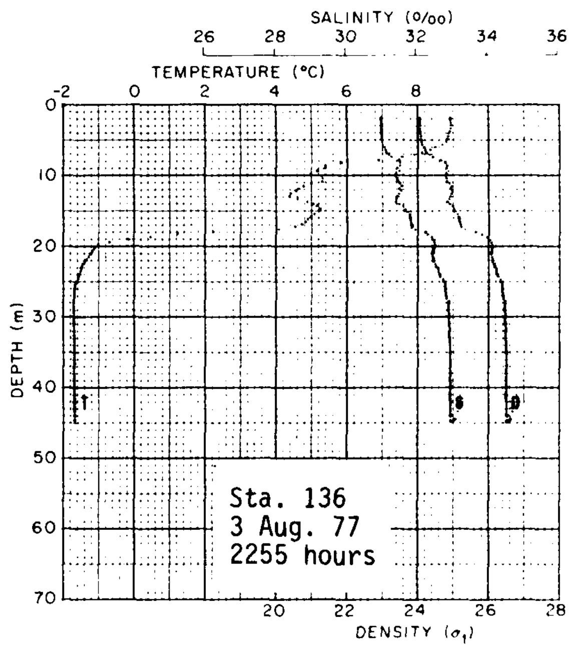
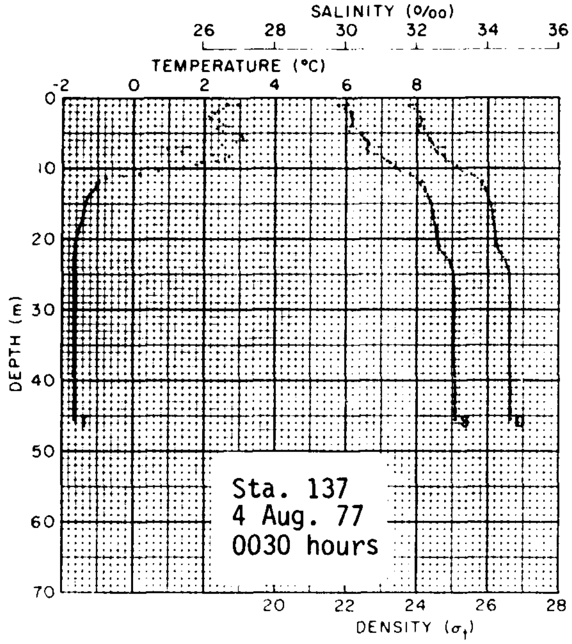
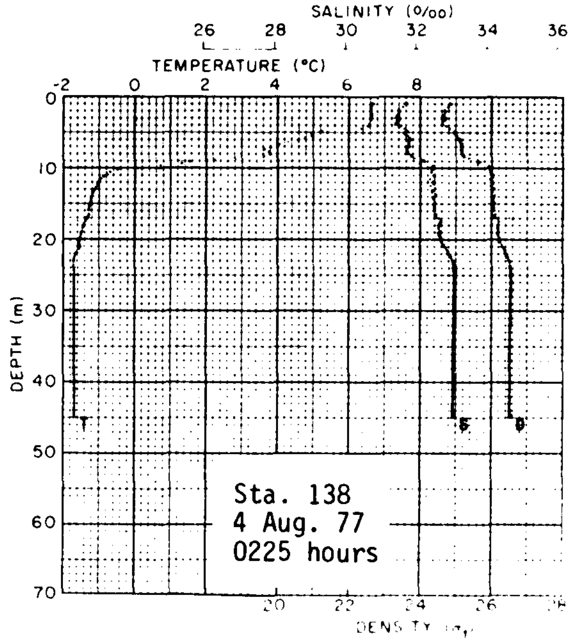
DEPTH (m)
0 10 20 30 40 50 60 70
Sta. 132
3 Aug. 77
1455 hours
20 22 24 26 28
DENSITY (σ_t)

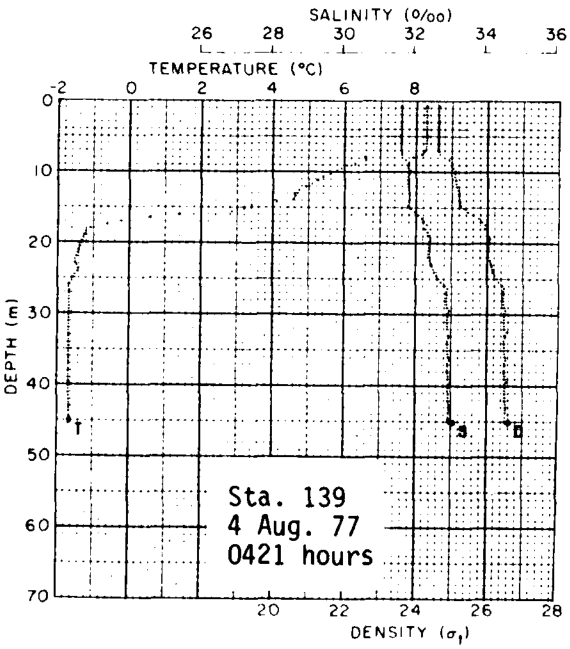

SALINITY (o/oo)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
Sta. 133
3 Aug. 77
1825 hours
20 22 24 26 28
DENSITY (σ_t)

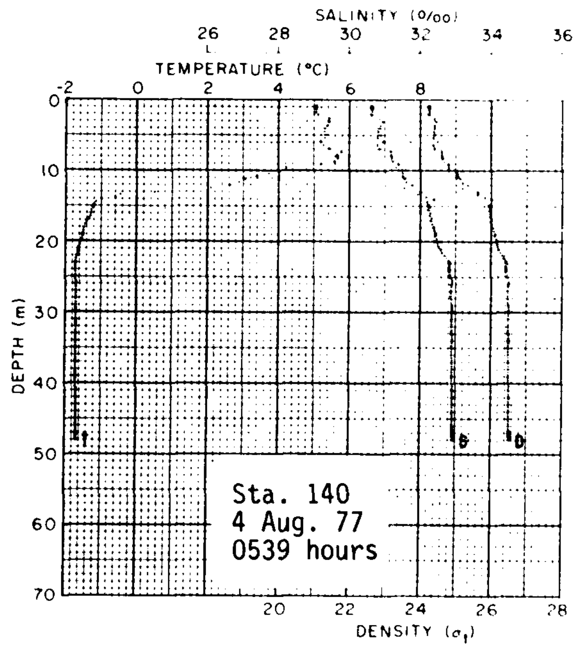

SALINITY (o/oo)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
Sta. 135
3 Aug. 77
2120 hours
20 22 24 26 28
DENSITY (σ_t)

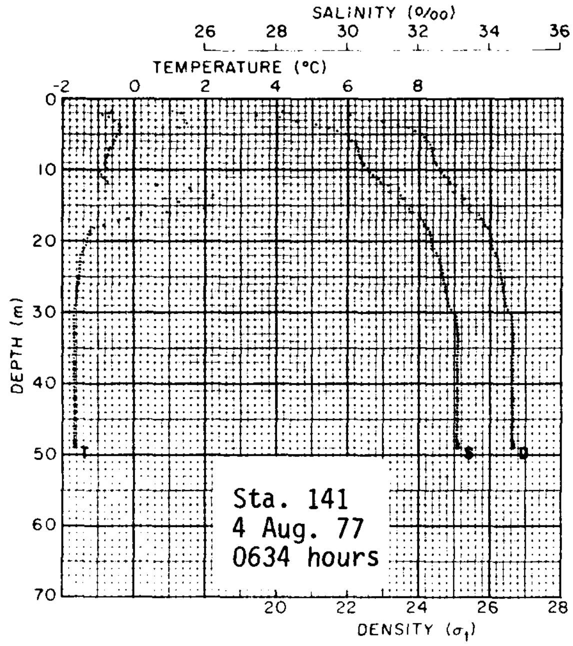

SALINITY (o/oo)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
Sta. 136
3 Aug. 77
2255 hours
20 22 24 26 28
DENSITY (σ_t)

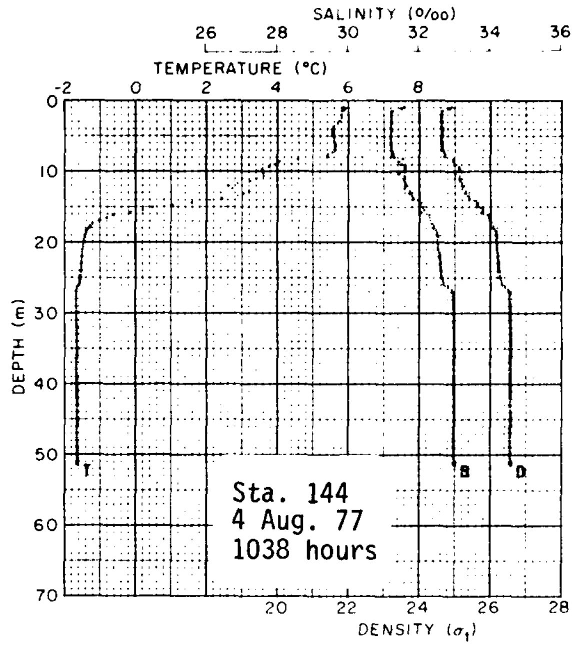

SALINITY (0/00)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
Sta. 137
4 Aug. 77
0030 hours
20 22 24 26 28
DENSITY (σ_t)

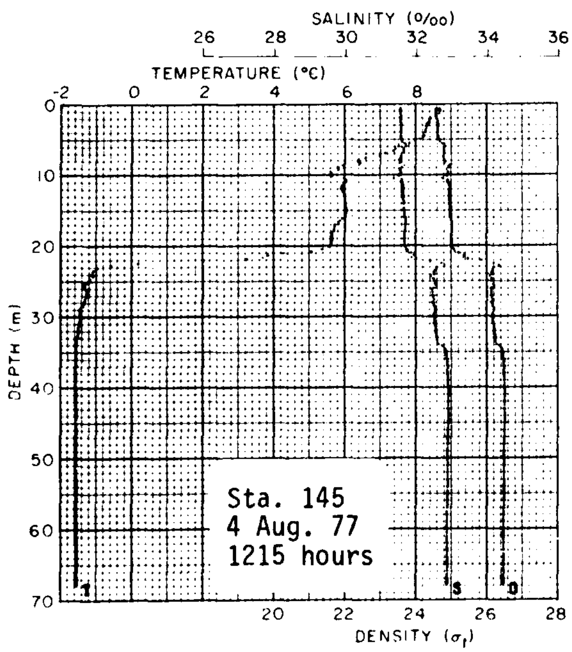

SALINITY (0/00)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
Sta. 138
4 Aug. 77
0225 hours

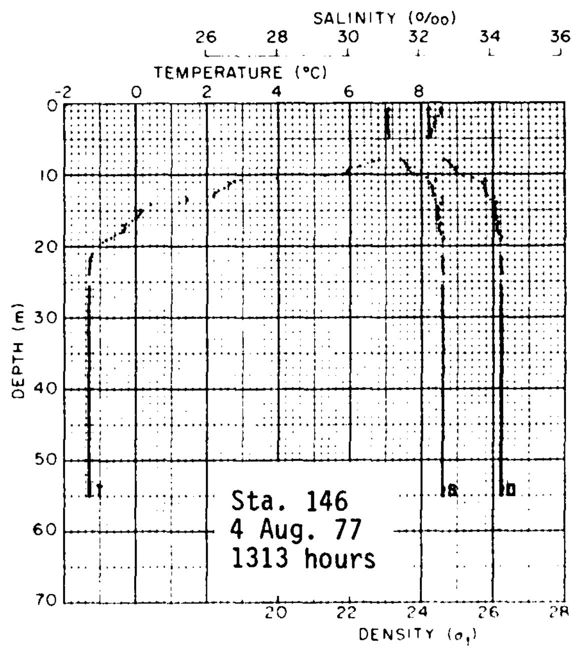

SALINITY (0/00)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
Sta. 139
4 Aug. 77
0421 hours
20 22 24 26 28
DENSITY (σ_t)

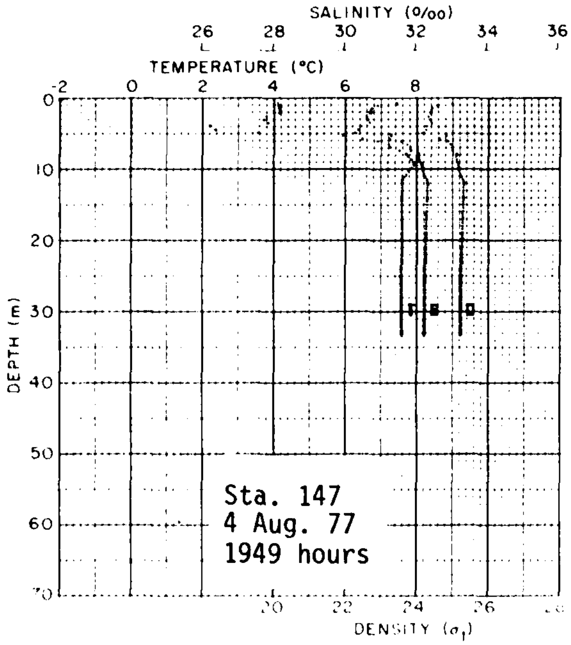

SALINITY (0/00)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
Sta. 140
4 Aug. 77
0539 hours
20 22 24 26 28
DENSITY (σ_t)

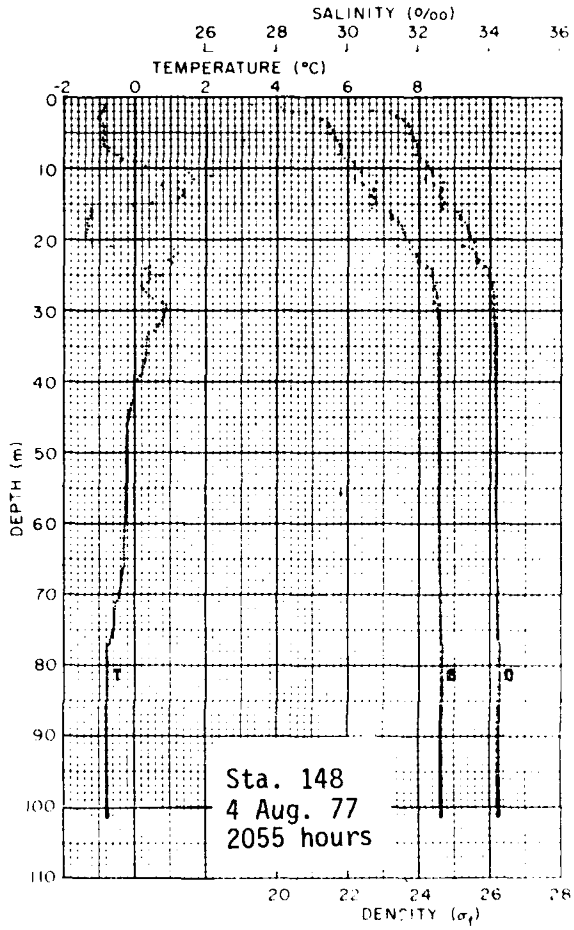

SALINITY (0/00)
TEMPERATURE (°C)
DEPTH (m)
DENSITY (σ_t)
Sta. 141
4 Aug. 77
0634 hours

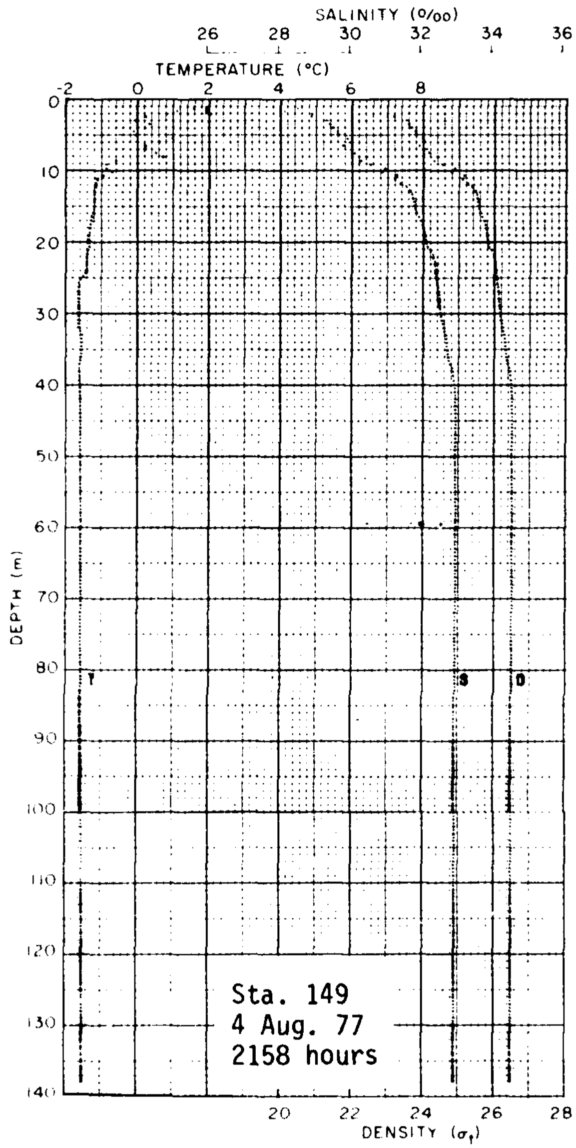

SALINITY (0/00)
TEMPERATURE (°C)
DEPTH (m)
DENSITY (σ_t)
Sta. 144
4 Aug. 77
1038 hours

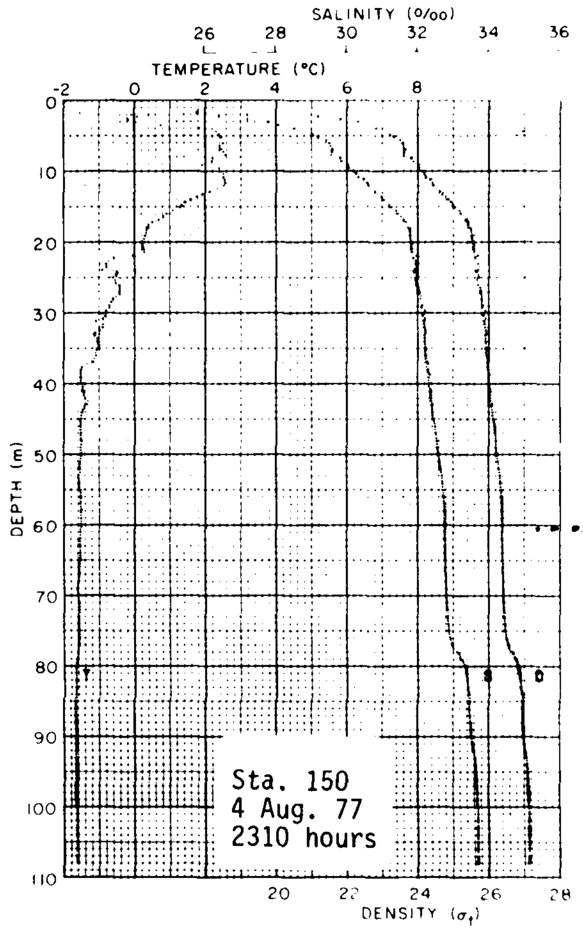

SALINITY (0/00)
TEMPERATURE (°C)
DEPTH (m)
DENSITY (σ_t)
Sta. 145
4 Aug. 77
1215 hours

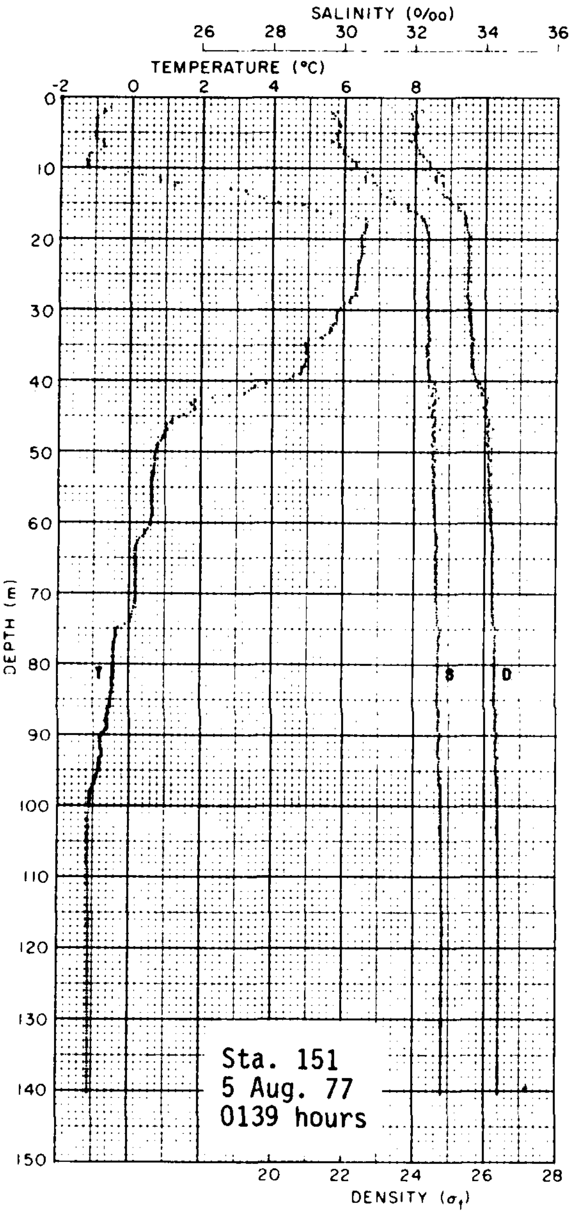

SALINITY (0/00)
TEMPERATURE (°C)
DEPTH (m)
DENSITY (σ_t)
Sta. 146
4 Aug. 77
1313 hours

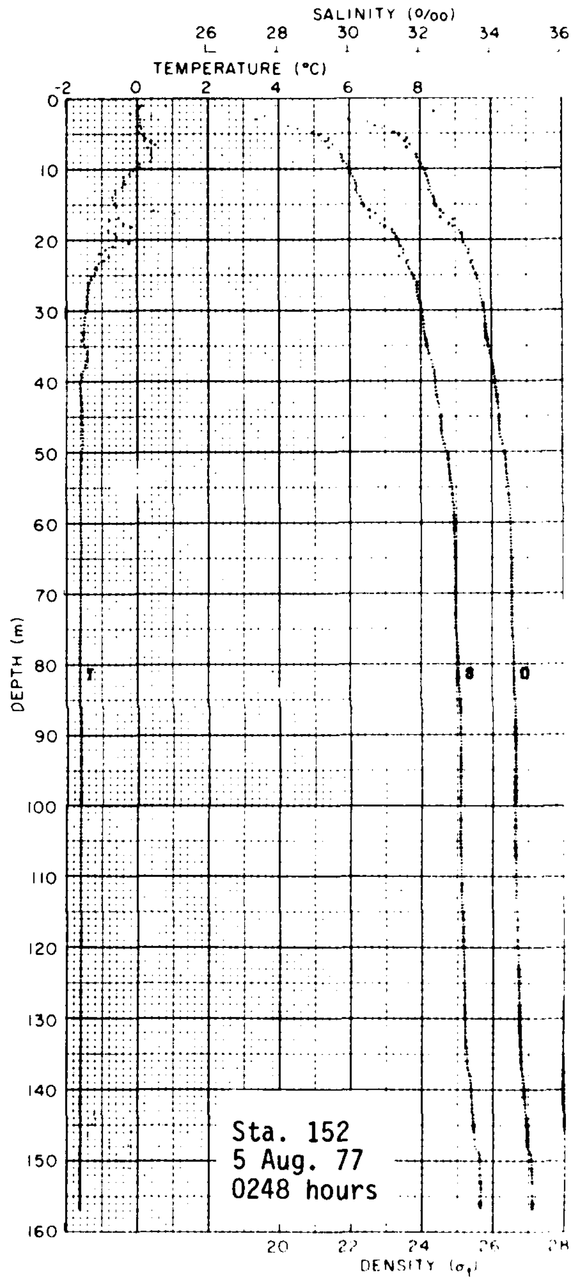

SALINITY (0/00)
TEMPERATURE (°C)
DEPTH (m)
DENSITY (σ_t)
Sta. 147
4 Aug. 77
1949 hours

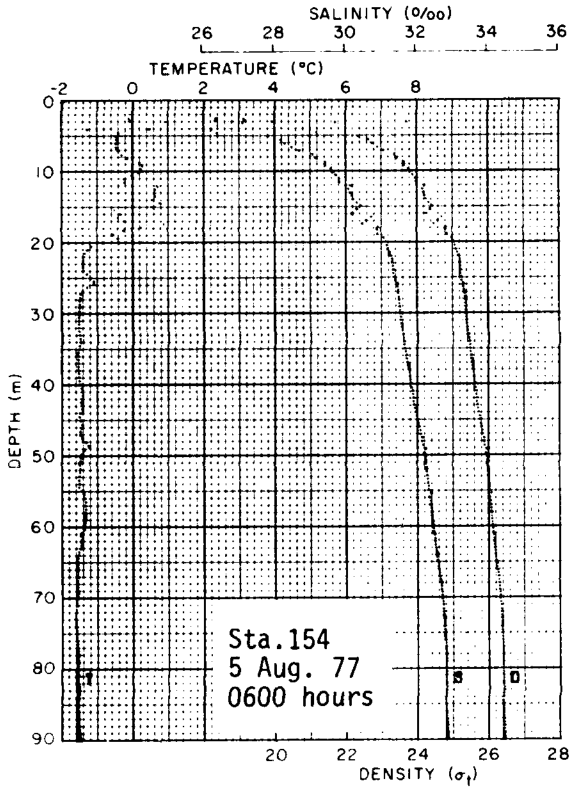

SALINITY (0/00)
TEMPERATURE (°C)
DEPTH (m)
DENSITY (σ_t)
Sta. 148
4 Aug. 77
2055 hours

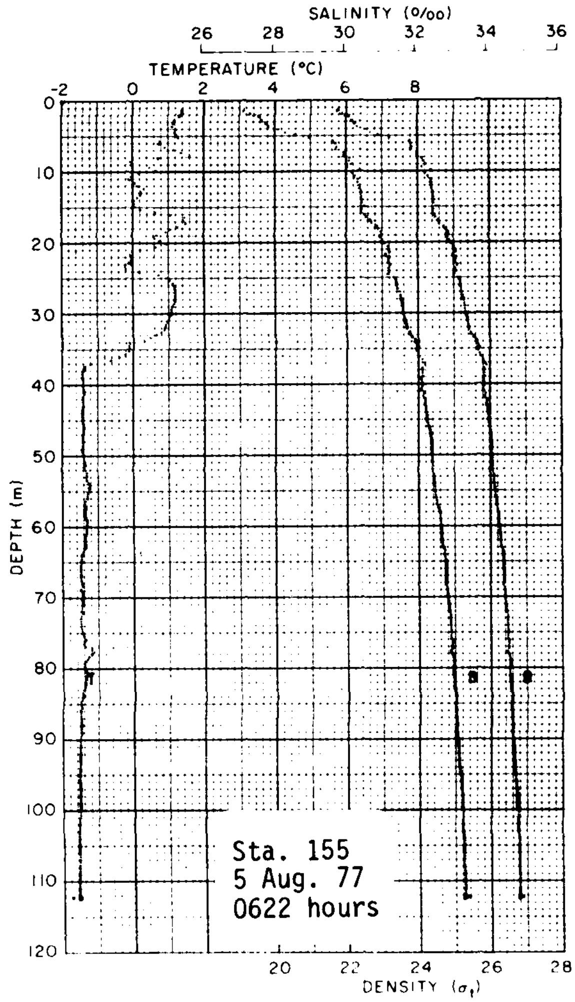

SALINITY (0/00)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140
T
S
D
Sta. 149
4 Aug. 77
2158 hours
20 22 24 26 28
DENSITY (σ_t)

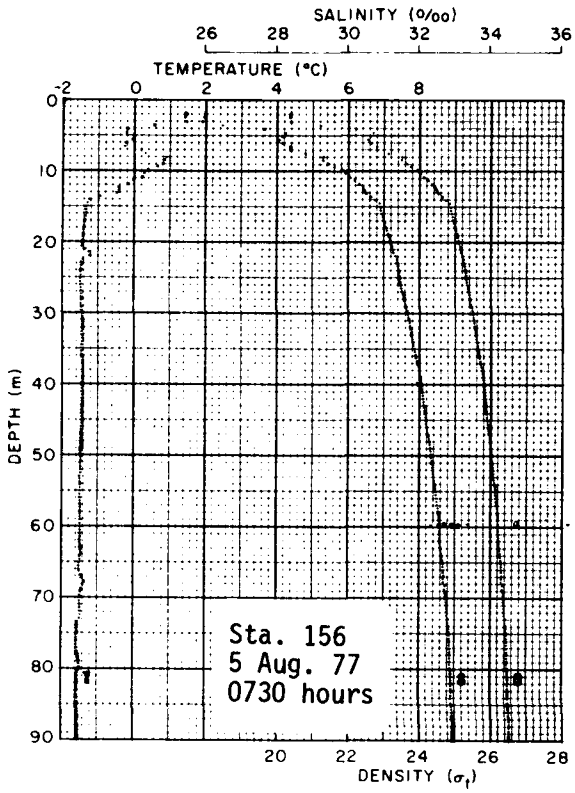

SALINITY (0/00)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110
T
S
D
Sta. 150
4 Aug. 77
2310 hours
20 22 24 26 28
DENSITY (σ_t)

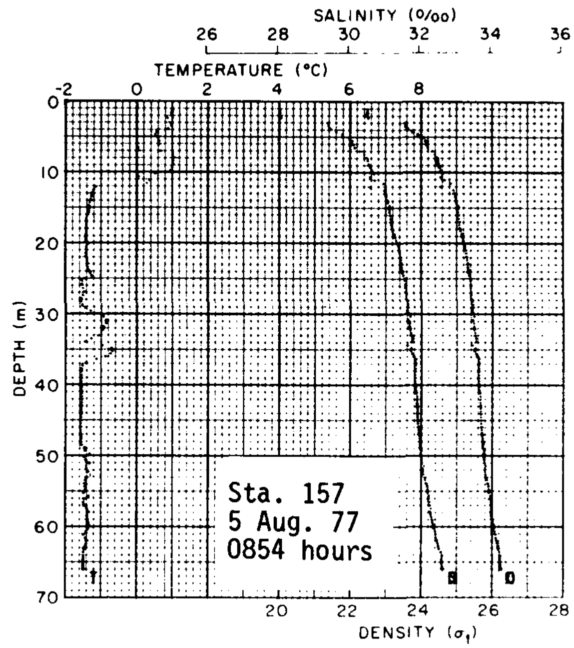

SALINITY (0/00)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
T
S
D
Sta. 151
5 Aug. 77
0139 hours
20 22 24 26 28
DENSITY (σ_t)


SALINITY (0/00)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
T
S
D
Sta. 152
5 Aug. 77
0248 hours
20 22 24 26 28
DENSITY (σ_t)


SALINITY (o/oo)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70 80 90
Sta.154
5 Aug. 77
0600 hours
T
S
D
20 22 24 26 28
DENSITY (σ_t)


SALINITY (o/oo)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120
Sta. 155
5 Aug. 77
0622 hours
T
S
D
20 22 24 26 28
DENSITY (σ_t)


SALINITY (0/00)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70 80 90
DENSITY (σ_t)
20 22 24 26 28
Sta. 156
5 Aug. 77
0730 hours

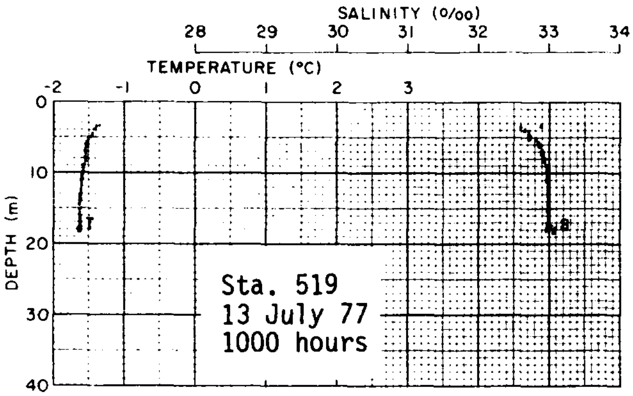

SALINITY (0/00)
26 28 30 32 34 36
TEMPERATURE (°C)
-2 0 2 4 6 8
DEPTH (m)
0 10 20 30 40 50 60 70
DENSITY (σ_t)
20 22 24 26 28
Sta. 157
5 Aug. 77
0854 hours

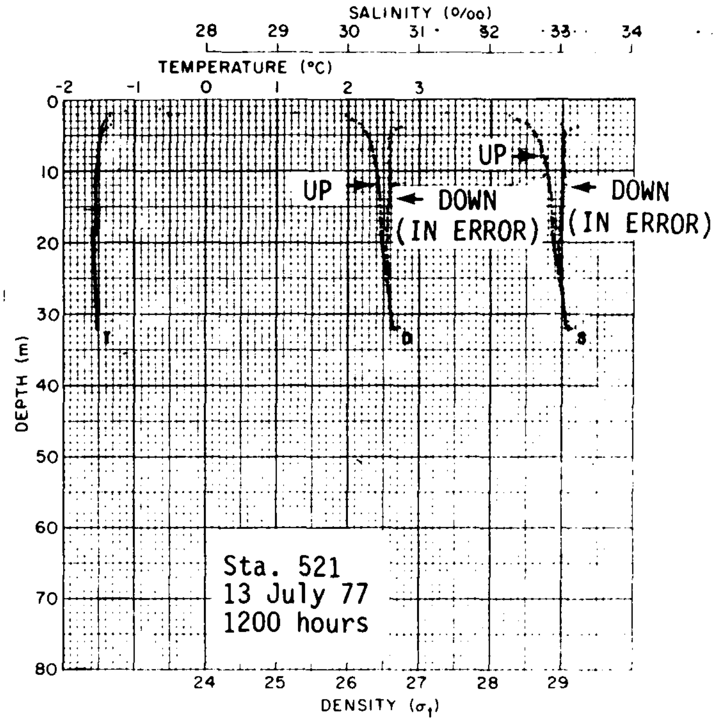
APPENDIX E

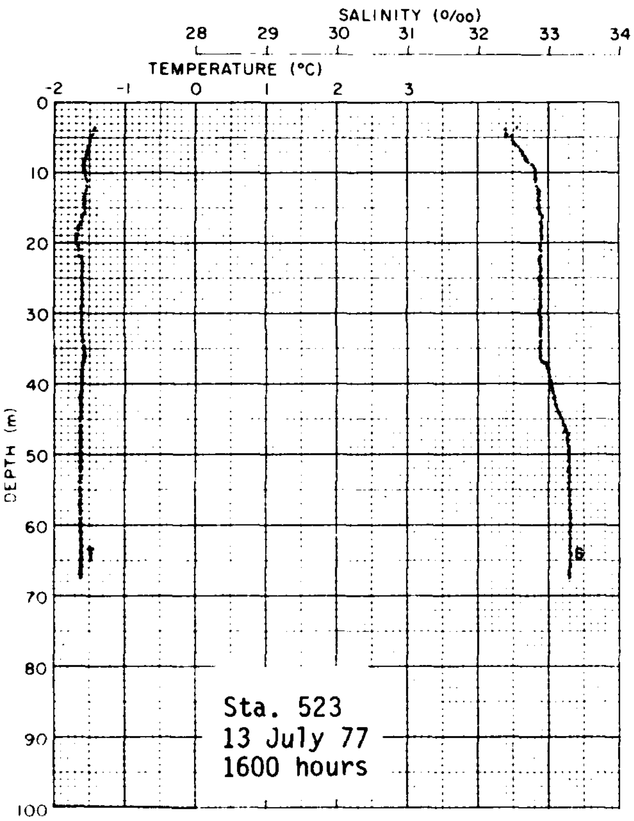
OCEANOGRAPHIC DATA AT ICE CAMP APLIS
AFTER STARTING DRIFT TO WEST
JULY 1977

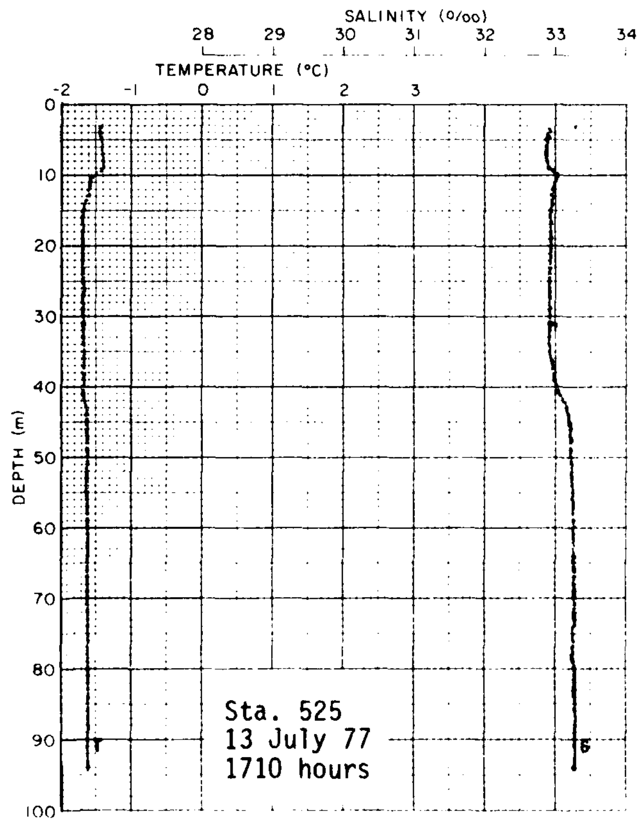
The locations of the CTD stations taken during drift are shown in Figure 21, p. 29.

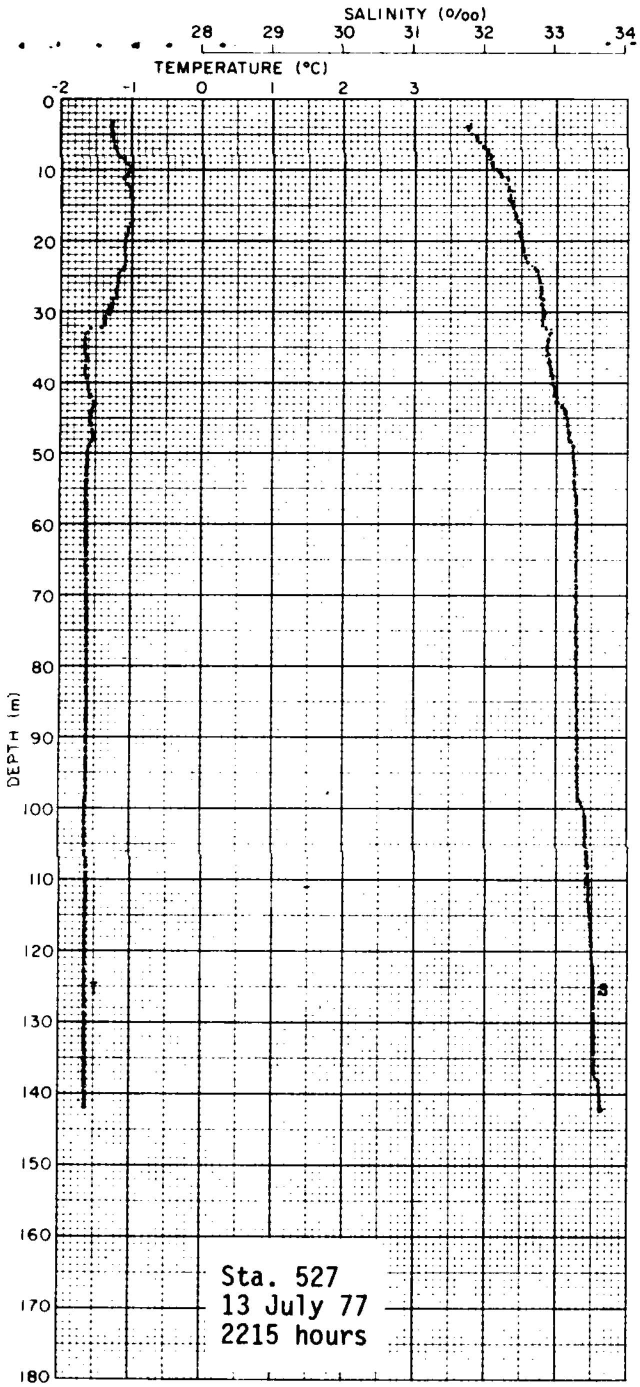
Station	Date	Local Time	Station	Date	Local Time
519	13 July	1000	545	16 July	0800
521		1200	547		1440
523		1600	549		2115
525		1710			
527		2215	551	17 July	0615
			553		1400
529	14 July	0825	555		2000
531		1540			
533		2215	557	18 July	0700
			559		1400
535	15 July	0740	561		1930
537		1230			
539		1245	563	19 July	0700
541		1800	565		1300
543		2230	567		1600

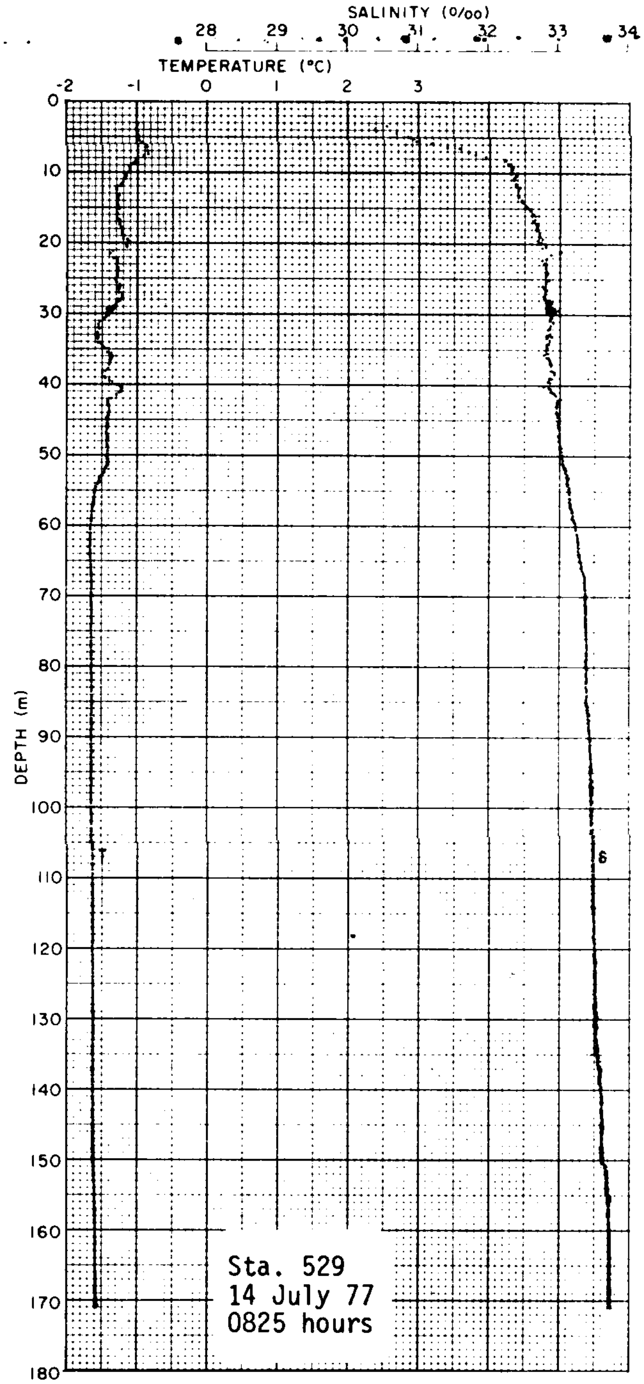

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40
T
S
Sta. 519
13 July 77
1000 hours

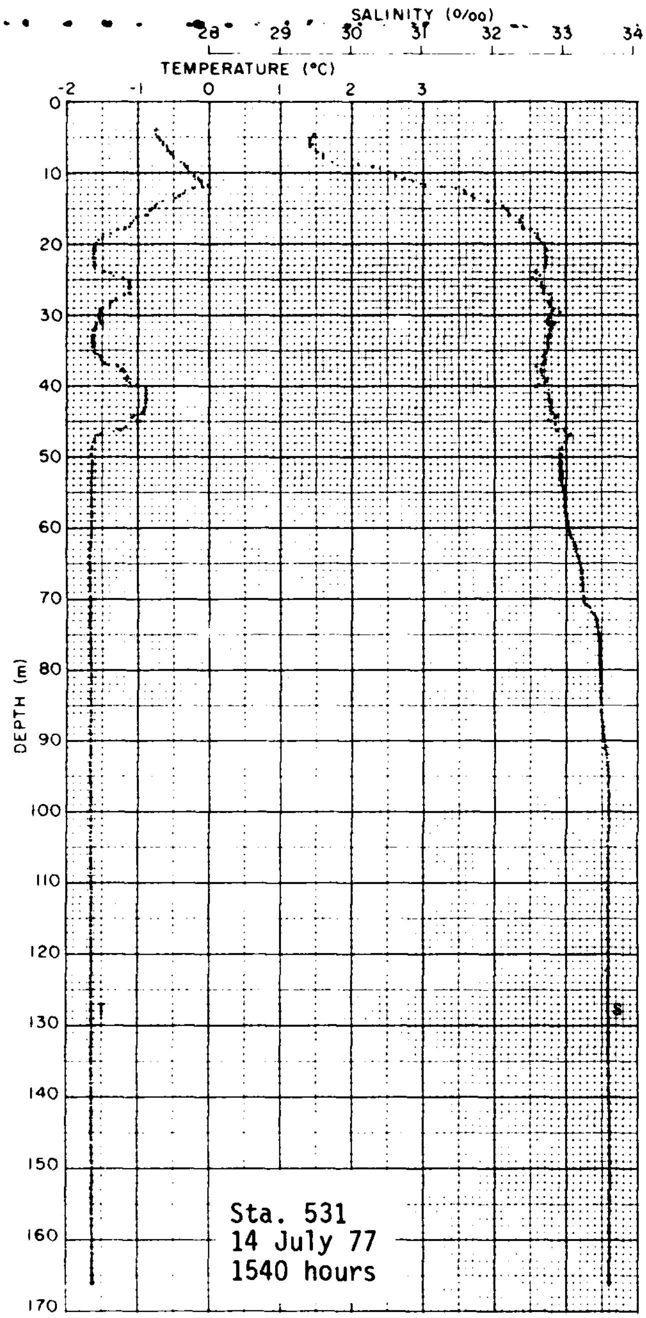

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80
UP
UP
DOWN
(IN ERROR)
DOWN
(IN ERROR)
T
D
S
Sta. 521
13 July 77
1200 hours
24 25 26 27 28 29
DENSITY (σ_t)

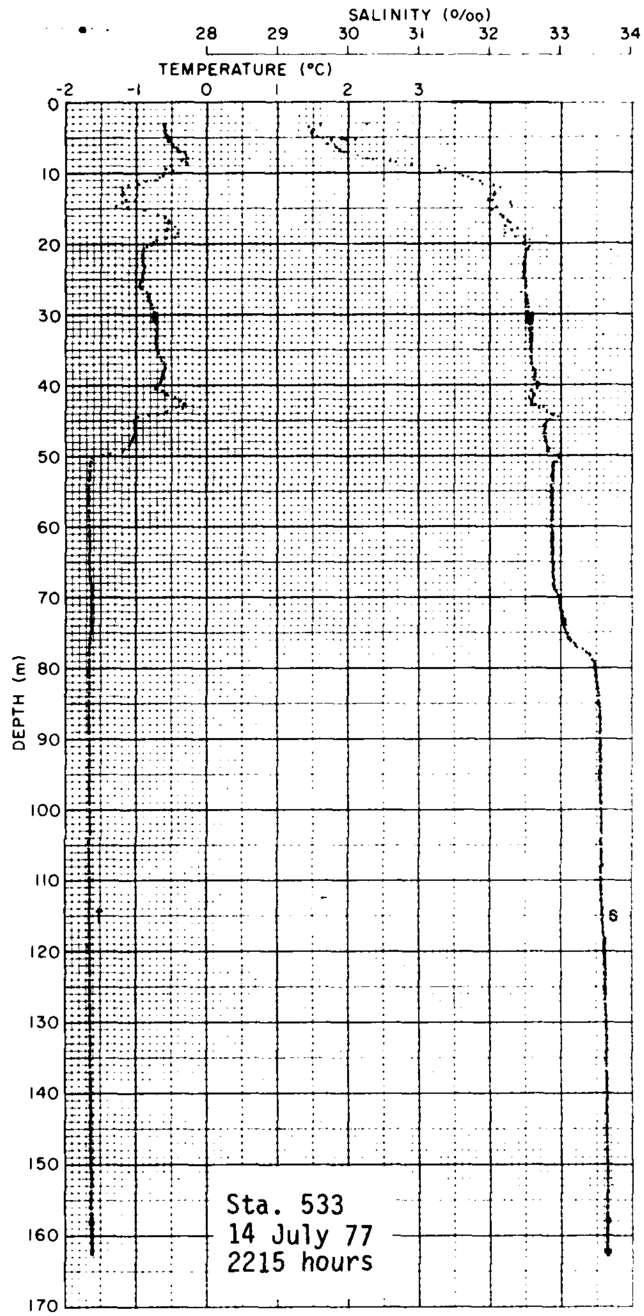

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100
T
S
Sta. 523
13 July 77
1600 hours

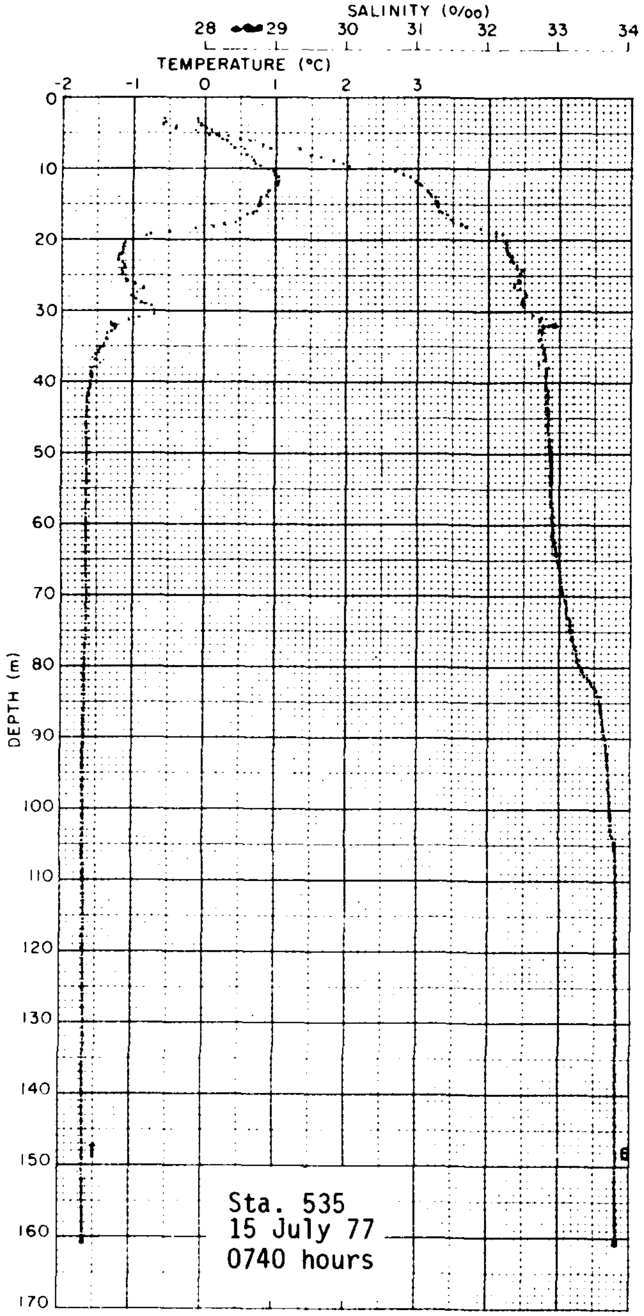

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100
T
S
Sta. 525
13 July 77
1710 hours


SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
T
S
Sta. 527
13 July 77
2215 hours

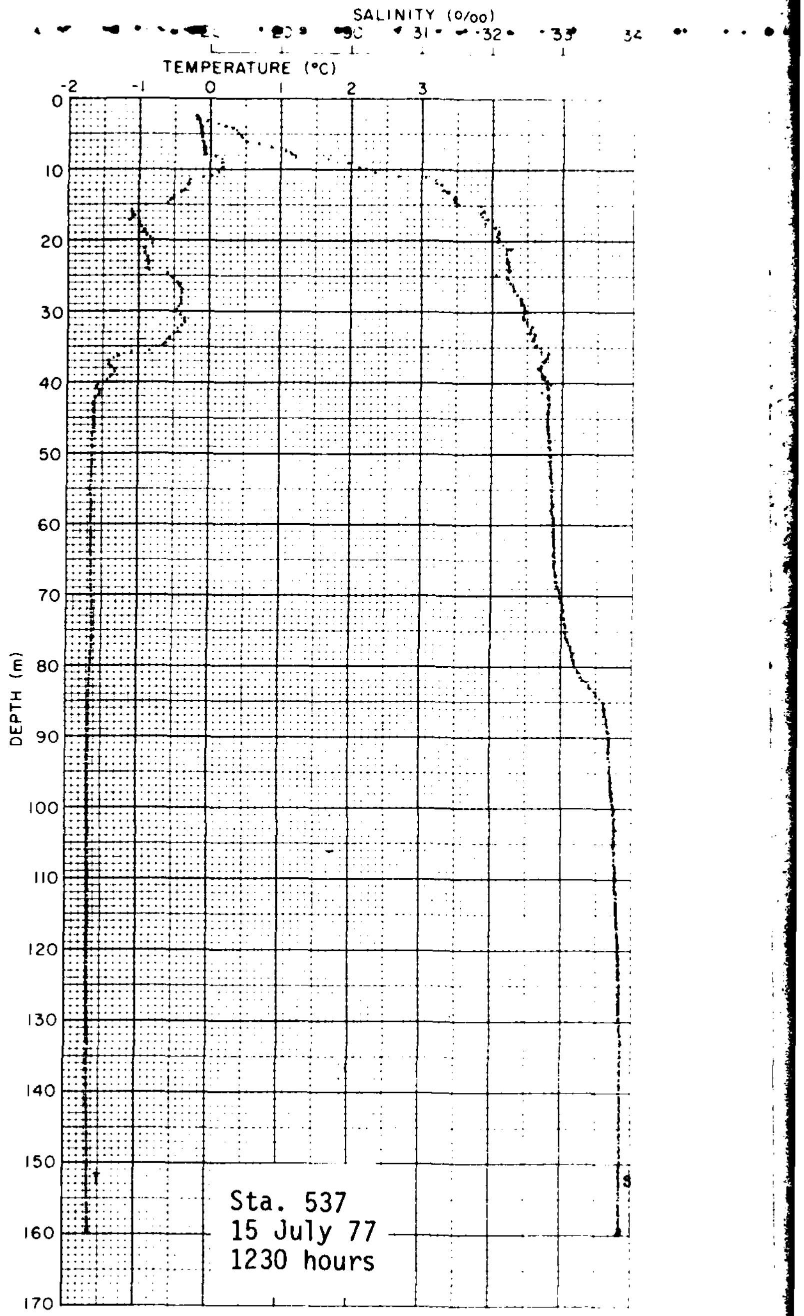

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
T
S
Sta. 529
14 July 77
0825 hours


SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
T
S
Sta. 531
14 July 77
1540 hours

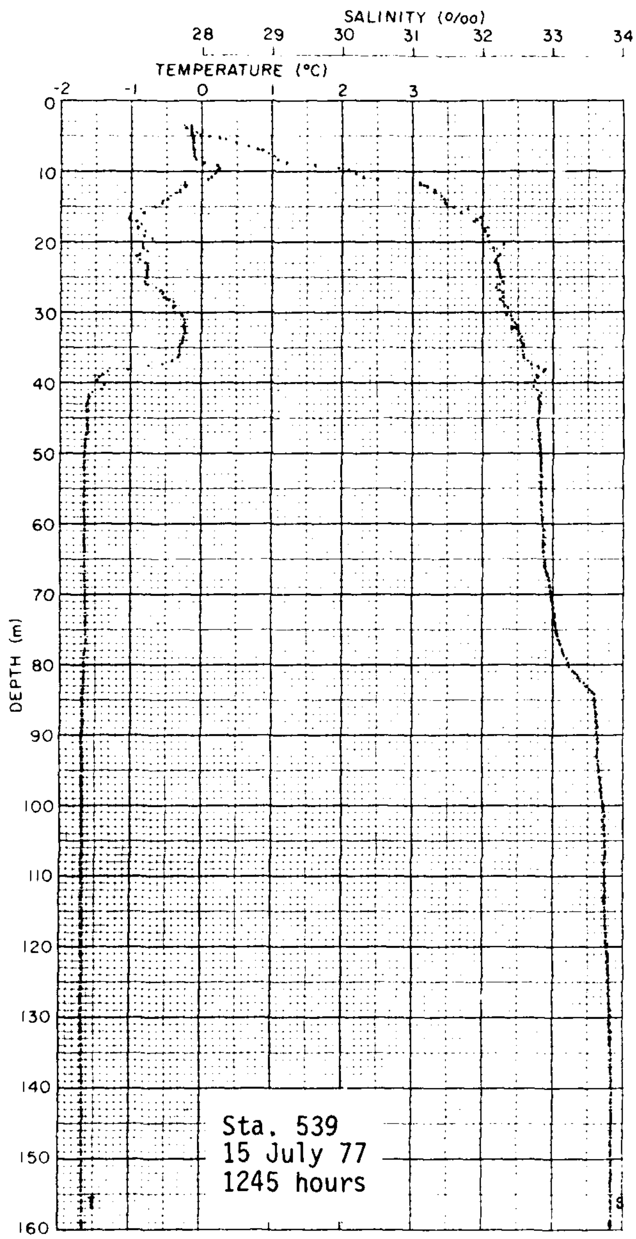

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
S
Sta. 533
14 July 77
2215 hours

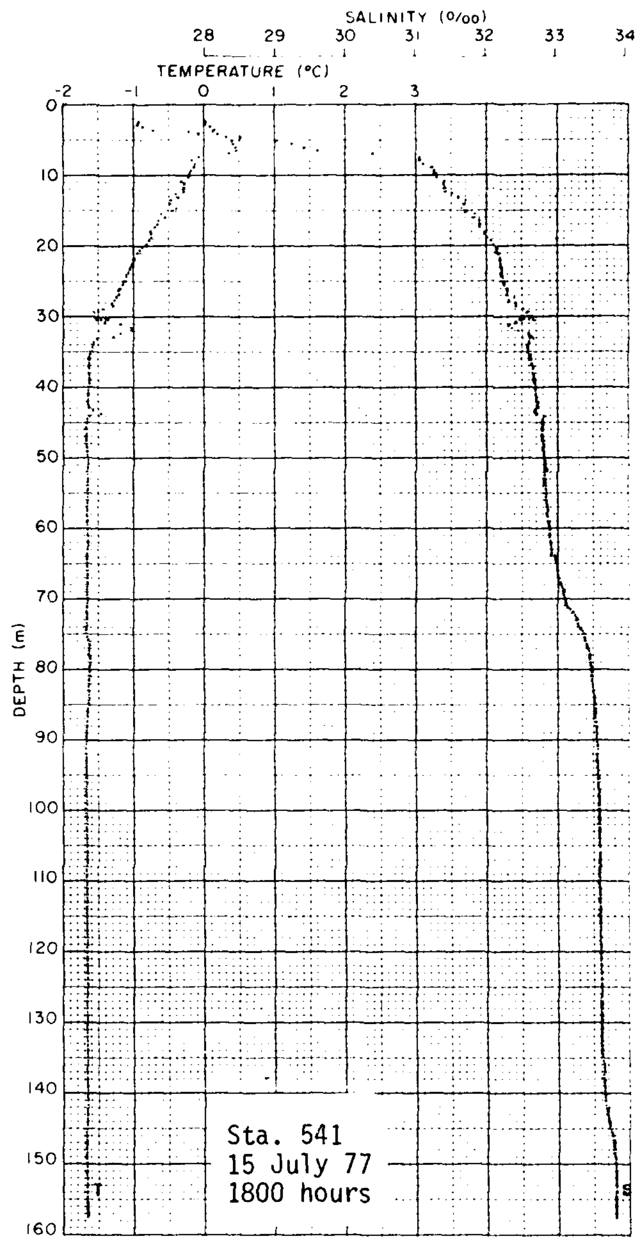


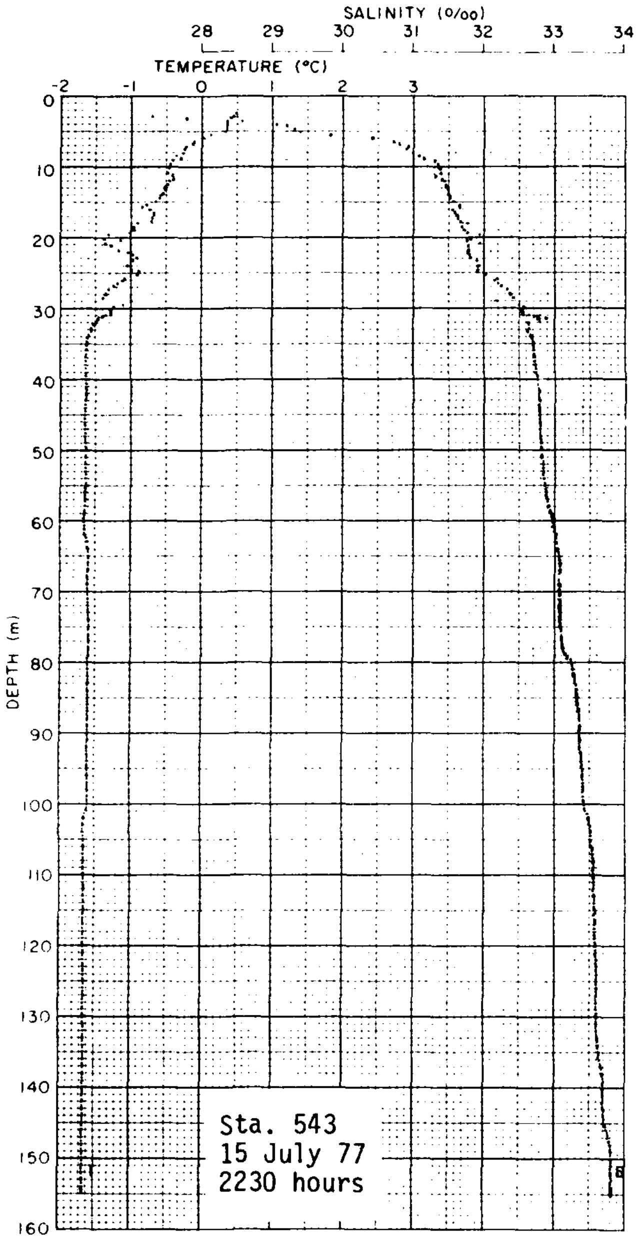
SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
T
S
Sta. 535
15 July 77
0740 hours

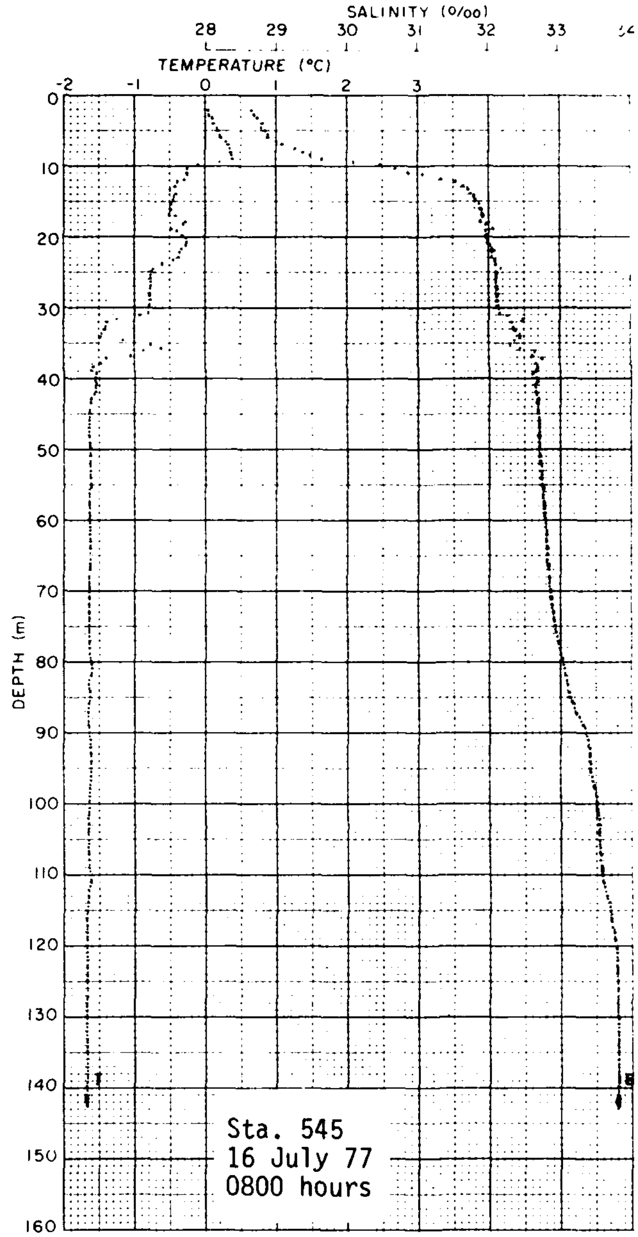


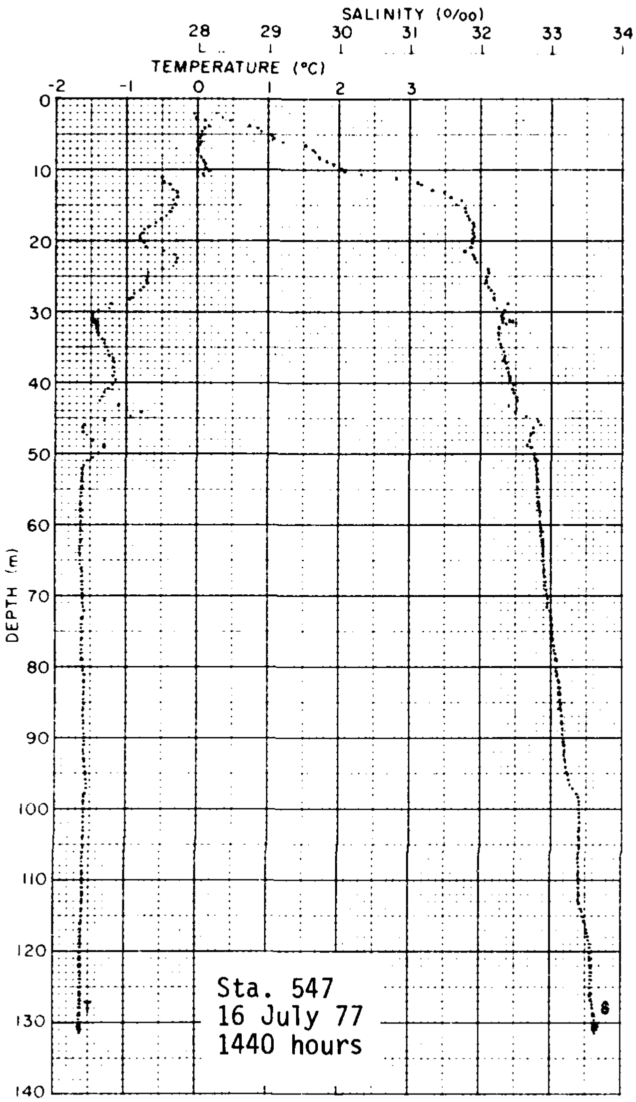
SALINITY (0/00)
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
T
S
Sta. 537
15 July 77
1230 hours

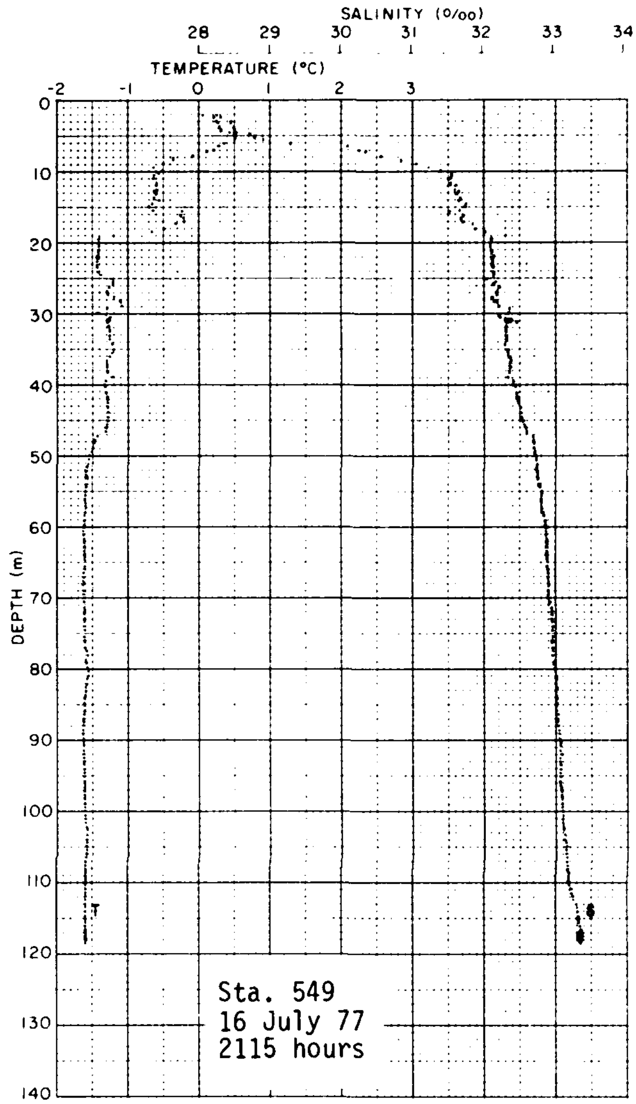

SALINITY (0/00)
TEMPERATURE (°C)
DEPTH (m)
Sta. 539
15 July 77
1245 hours

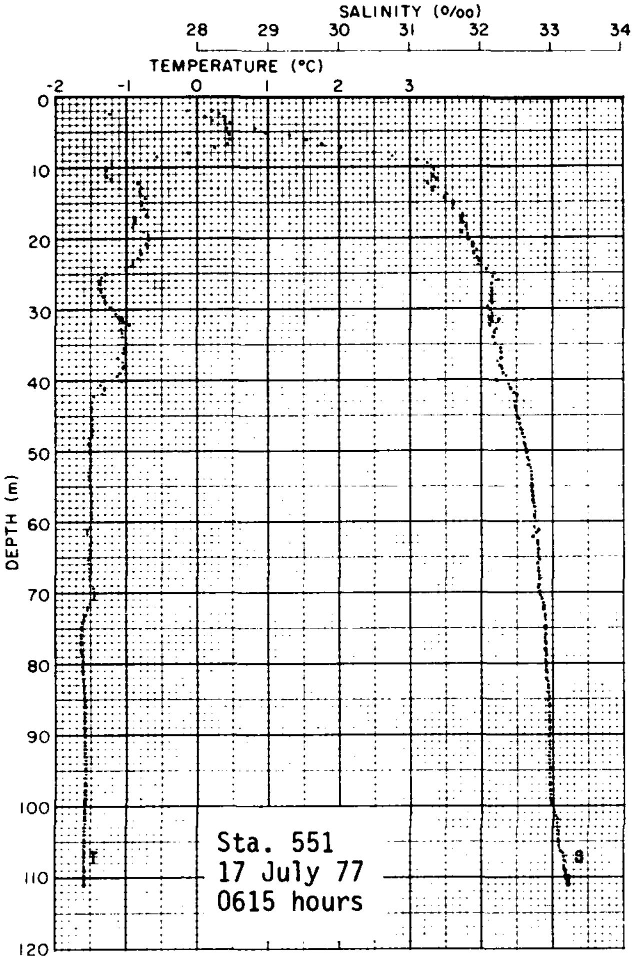

SALINITY (0/00)
TEMPERATURE (°C)
DEPTH (m)
Sta. 541
15 July 77
1800 hours

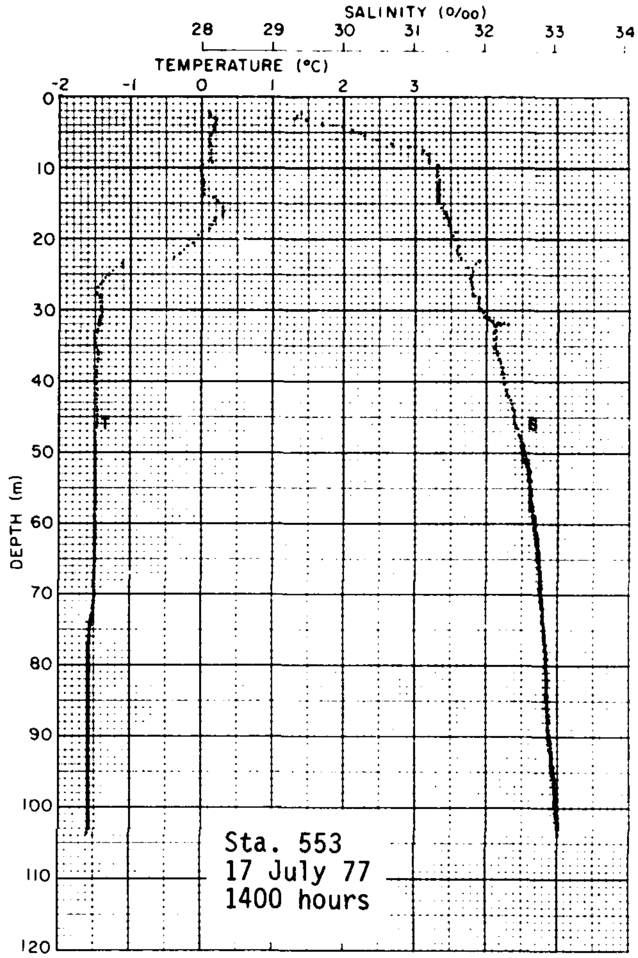

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
T
B
Sta. 543
15 July 77
2230 hours

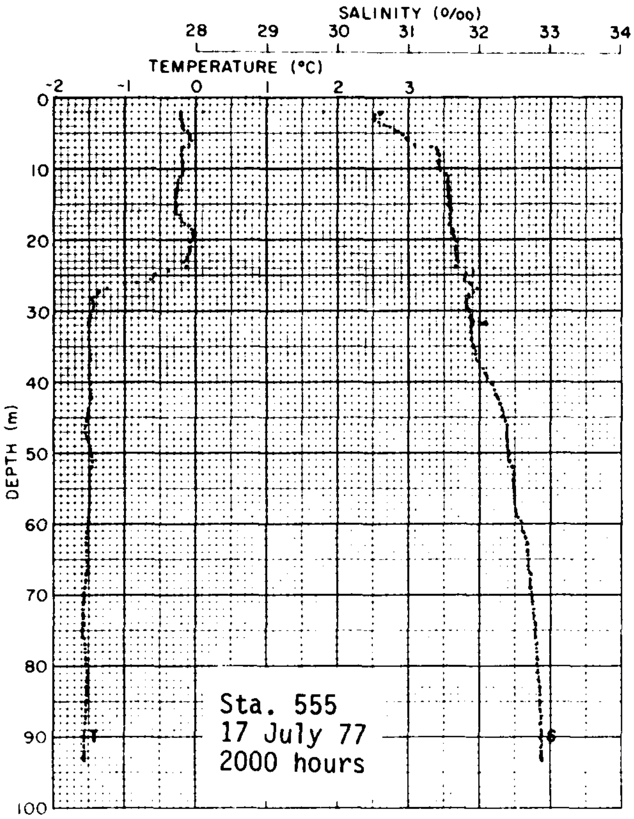

SALINITY (0/00)
28 29 30 31 32 33
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
T
B
Sta. 545
16 July 77
0800 hours

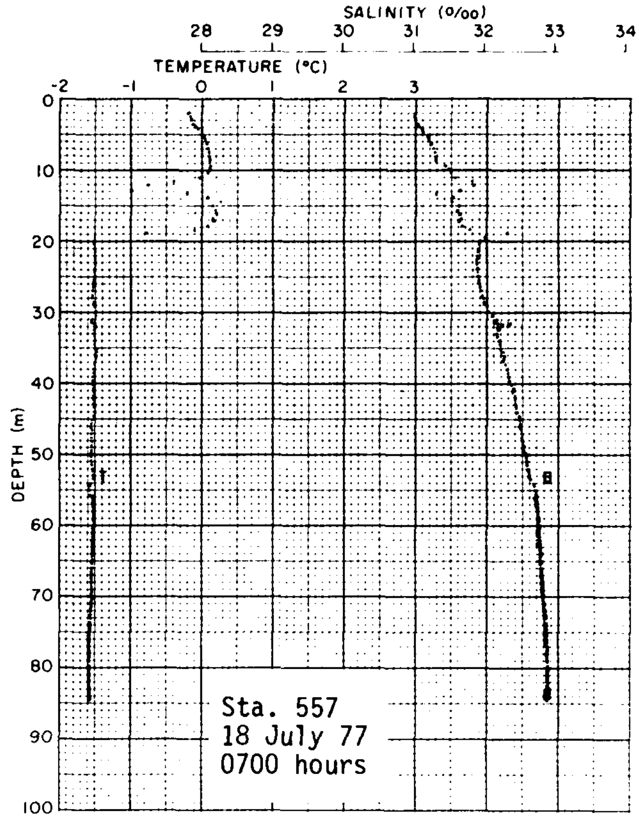

SALINITY (o/oo)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140
T
S
Sta. 547
16 July 77
1440 hours

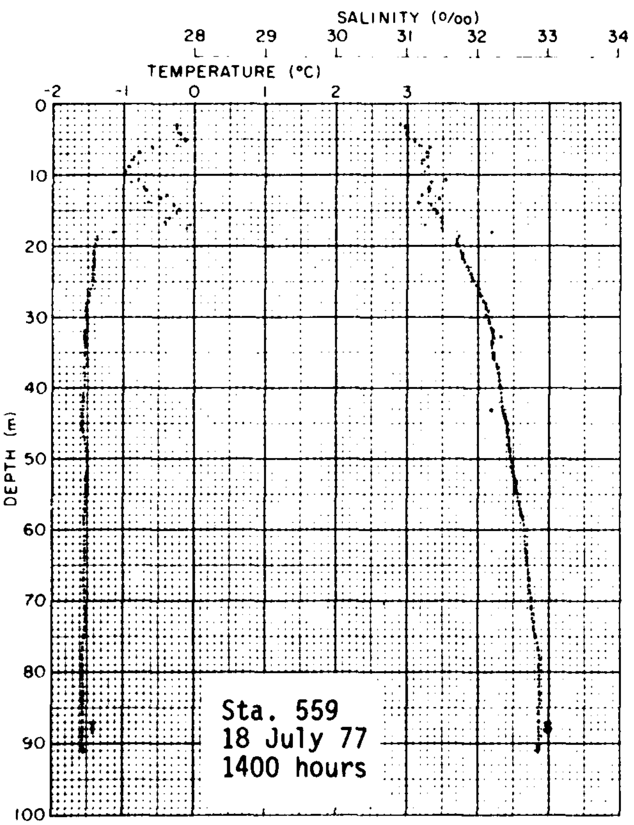

SALINITY (o/oo)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140
T
S
Sta. 549
16 July 77
2115 hours

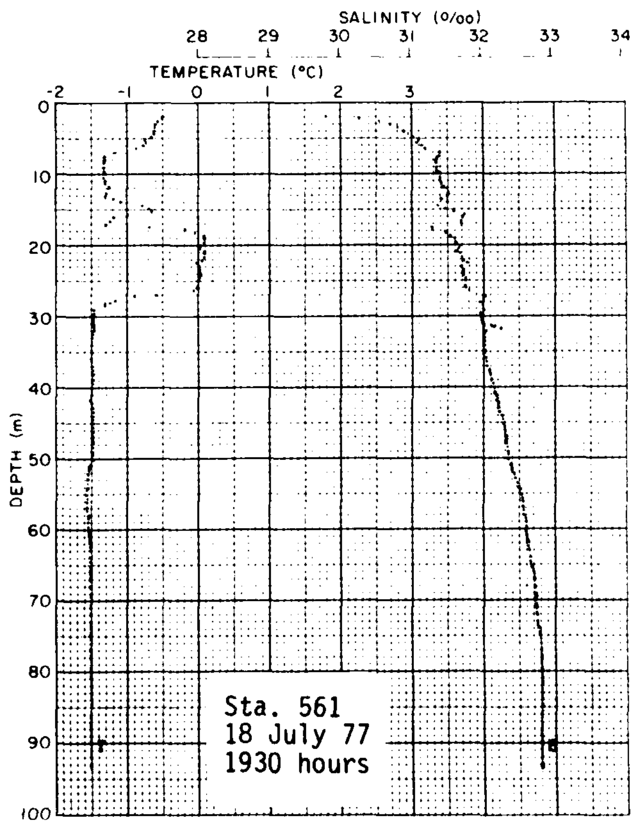

SALINITY (0/oo)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120
T
S
Sta. 551
17 July 77
0615 hours

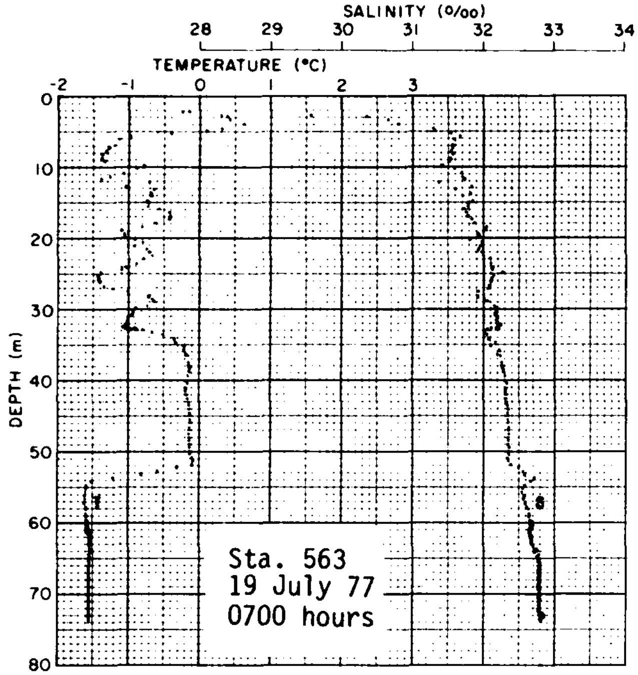

SALINITY (0/oo)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120
T
S
Sta. 553
17 July 77
1400 hours

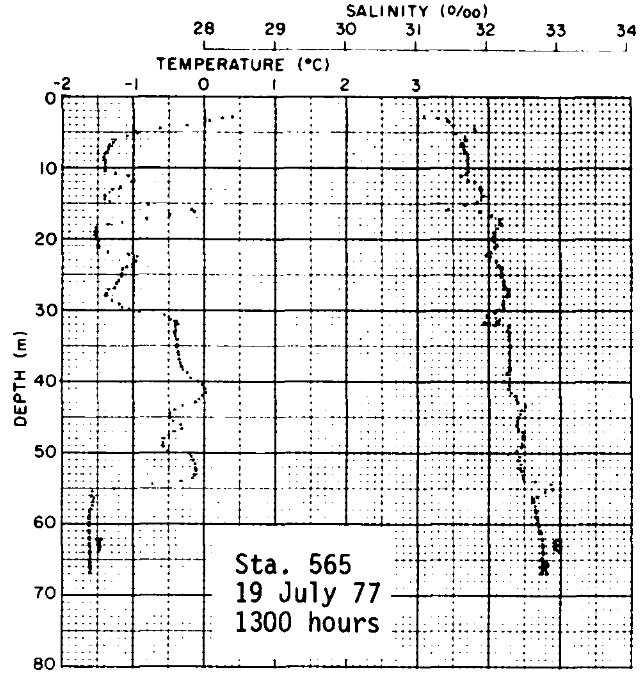

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100
Sta. 555
17 July 77
2000 hours

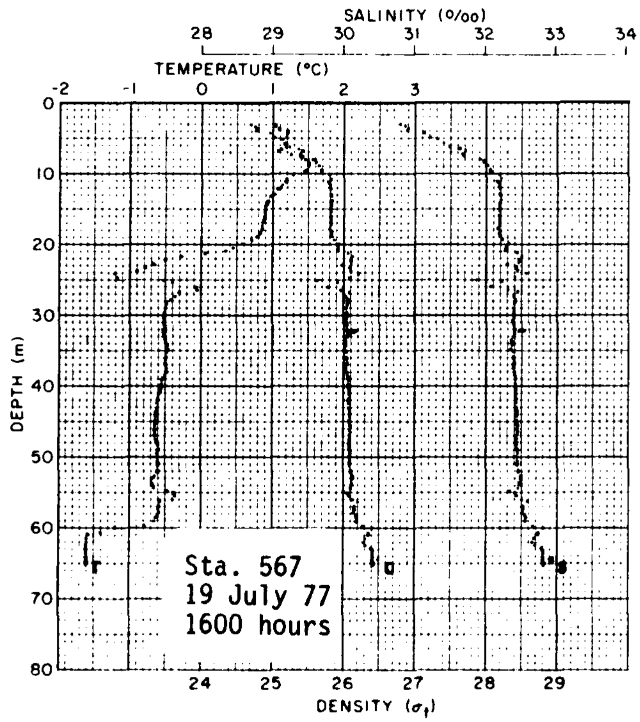

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100
Sta. 557
18 July 77
0700 hours


SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100
Sta. 559
18 July 77
1400 hours


SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100
Sta. 561
18 July 77
1930 hours


SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80
Sta. 563
19 July 77
0700 hours


SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80
Sta. 565
19 July 77
1300 hours


SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80
Sta. 567
19 July 77
1600 hours
24 25 26 27 28 29
DENSITY (σt)

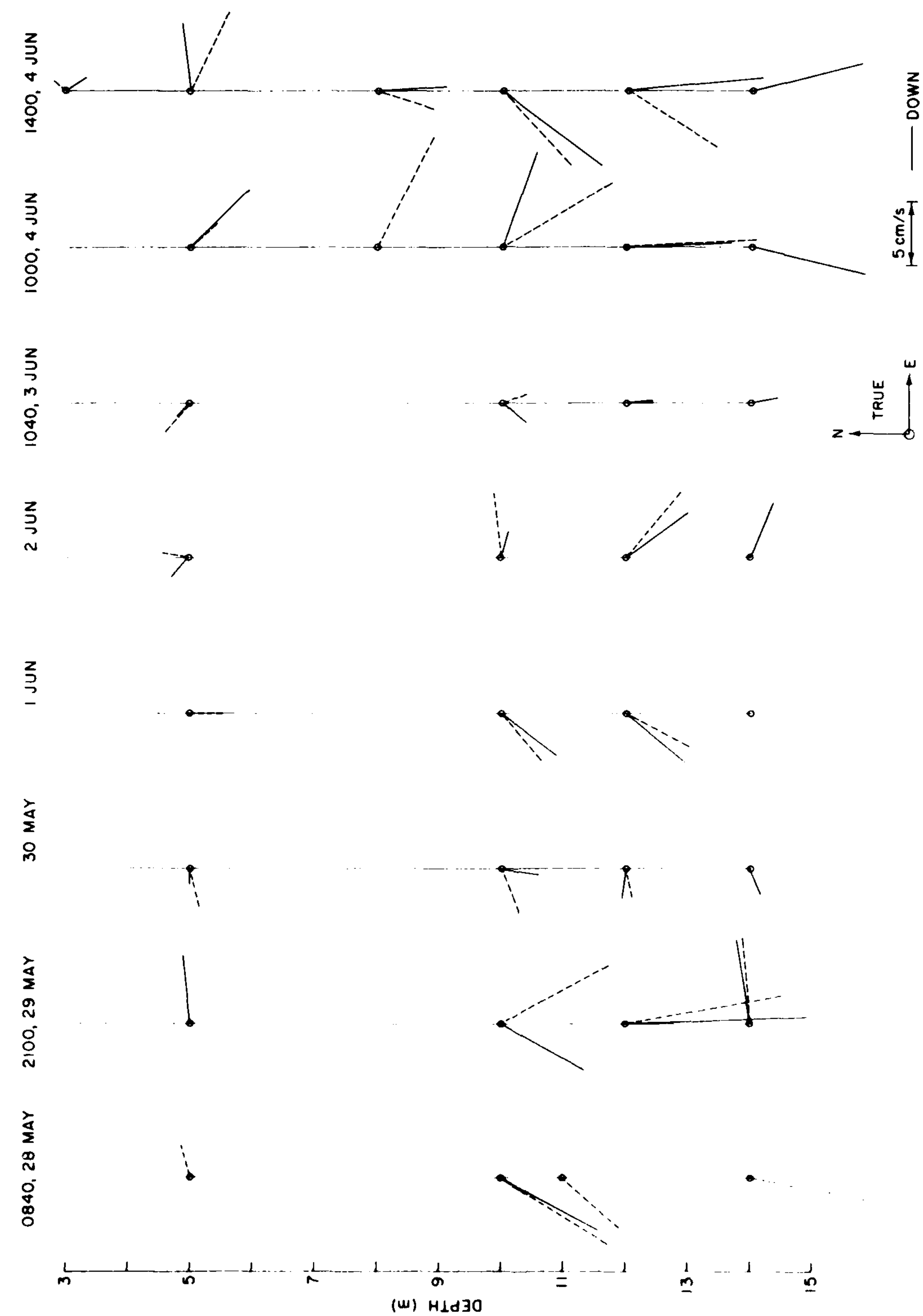
APPENDIX F

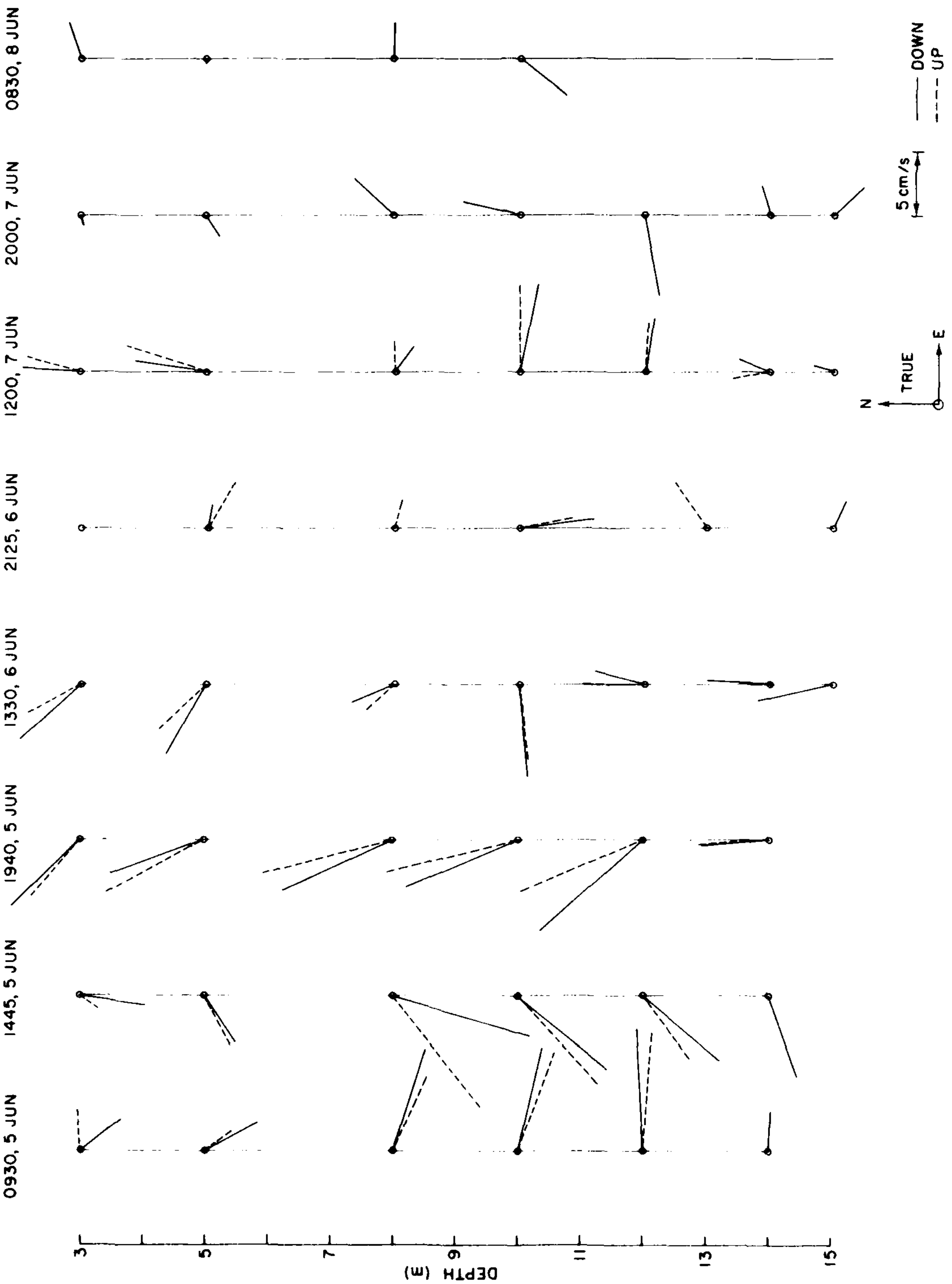
CURRENT MEASUREMENTS AT ICE CAMP APLIS WHILE STATIONARY IN SHORE-FAST ICE MAY-JULY 1977

Current measurements which were taken periodically at six depths before the floe started to drift are shown in this appendix and summarized in Figure 33. p. 45.

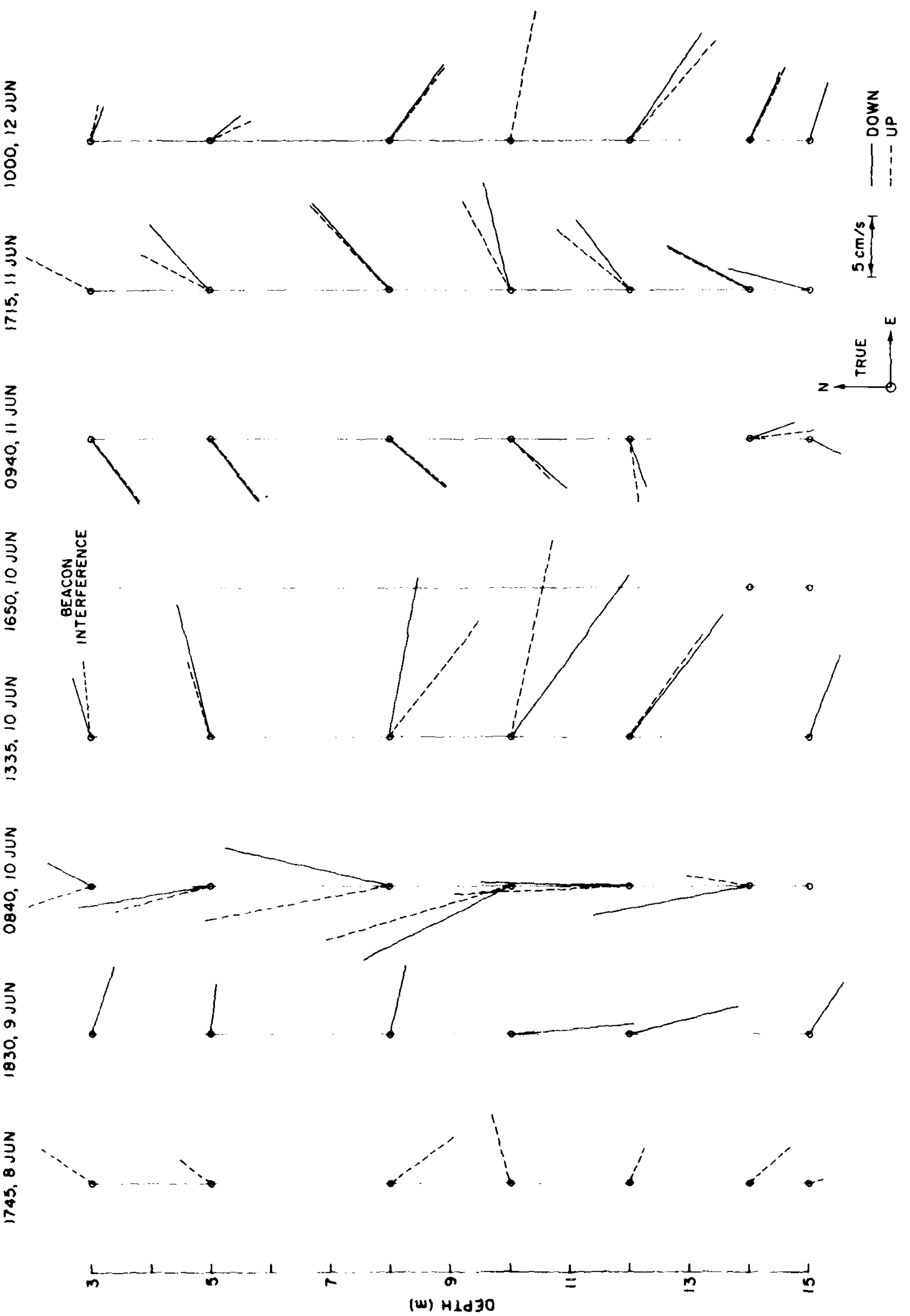
Date	Local Time
May 28	0840
29	2100
30	--
June 1	--
2	--
3	1040
4	1000
	1400
5	0930
	1445
	1940
6	1330
	2125
7	1200
	2000
8	0830
	1745
9	0935*
	1830
10	0840
	1335
	1650
11	0940
	1715
12	1000
	1600
13	0950
	1230
	1605
14	0935
	1605
15	0950
	1620
16	1145
	1650
	1900
	2100
June 17	0840
	2125
18	1000
	1715
19	1045
	1730
20	0730
	1700
21	1200
	1700
22	0930
	1630
23	0835
	1720
	2005
24	0005
	0605
	1005
	1408
	1800
25	1100
	1700
26	0800
	1650
27	0930
	1825
28	1030
	1720
29	0900
	1600
30	1000
	1630
July 1	0915
	1725
2	1050
	1630
July 3	0950
	1630
4	0805
	1310
	1610
	2010
5	0000
	0410
	0810
	1205
	1605
	2005
	2400
6	0930
	1720
7	0935
	1715
8	0930
	1630
9	1020
	1655
10	0930
	1650
11	1710
12	1010
	1645
13	0930**

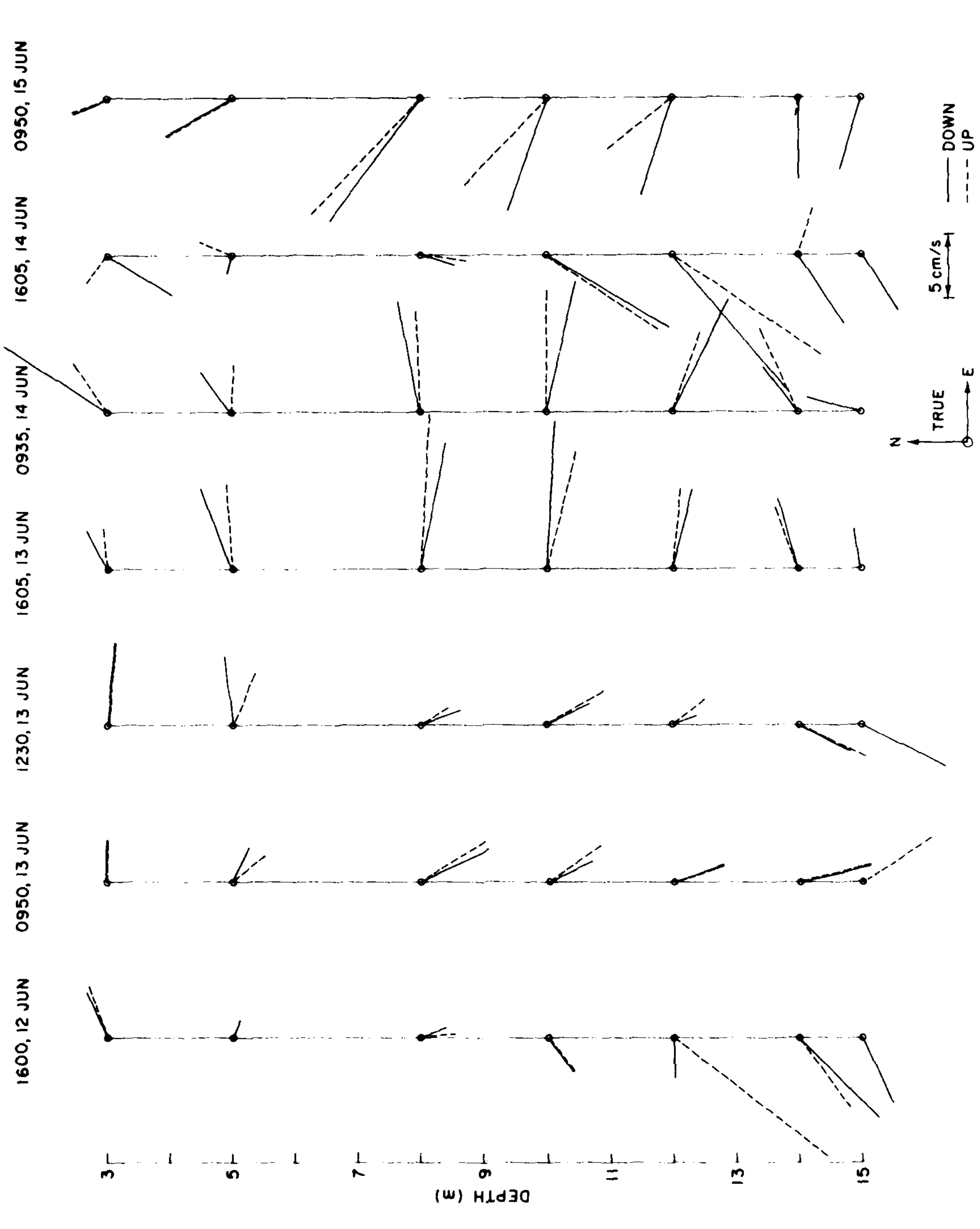
* Current small at all depths.
** Floe is probably adrift.

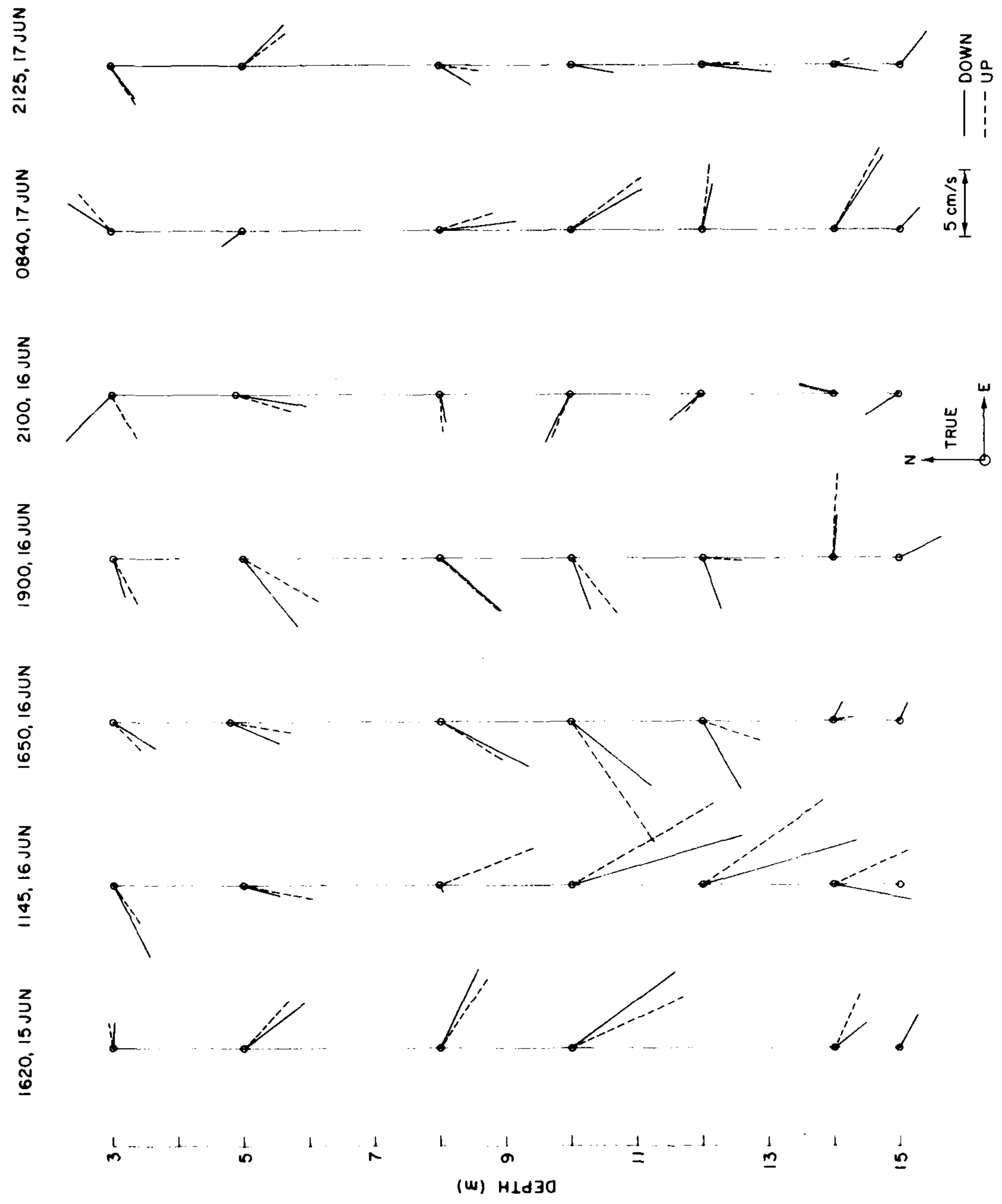

0840, 28 MAY
2100, 29 MAY
30 MAY
1 JUN
2 JUN
1040, 3 JUN
1000, 4 JUN
1400, 4 JUN
DEPTH (m)
3
5
7
9
11
13
15
TRUE
N
E
5 cm/s
DOWN
UP

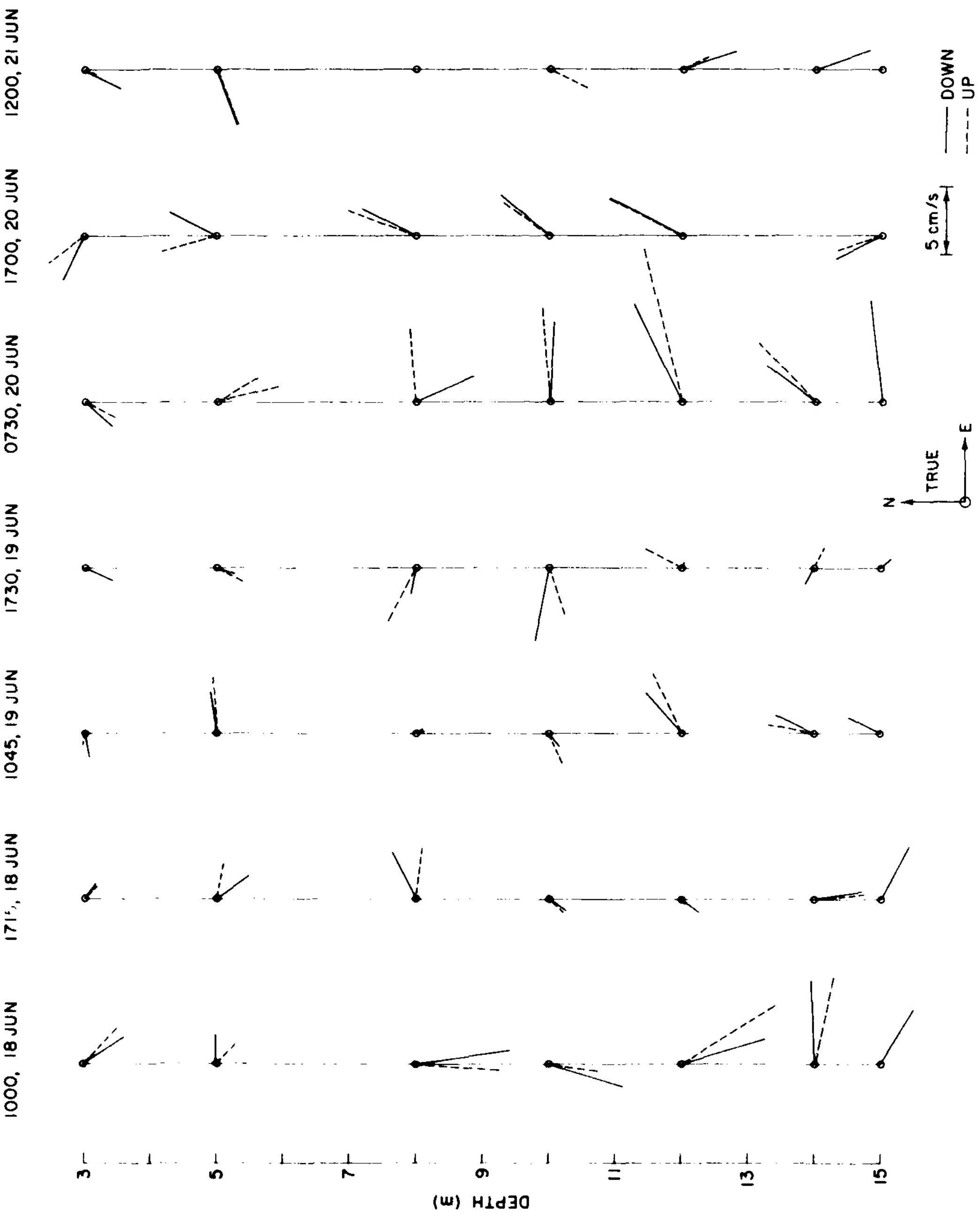


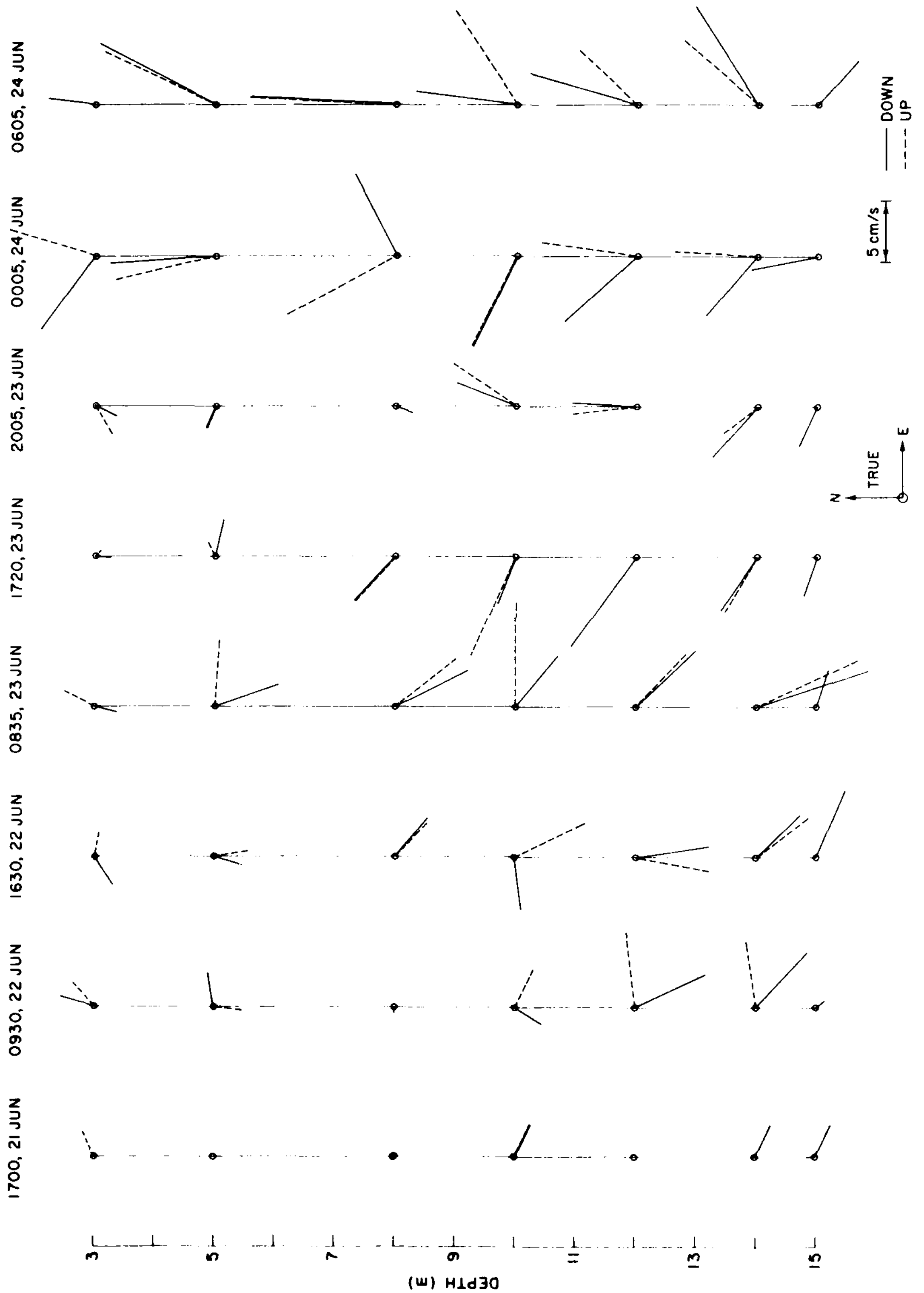
0930, 5 JUN
1445, 5 JUN
1940, 5 JUN
1330, 6 JUN
2125, 6 JUN
1200, 7 JUN
2000, 7 JUN
0830, 8 JUN
DEPTH (m)
3
5
7
9
11
13
15
TRUE
N
E
5 cm/s
DOWN
UP

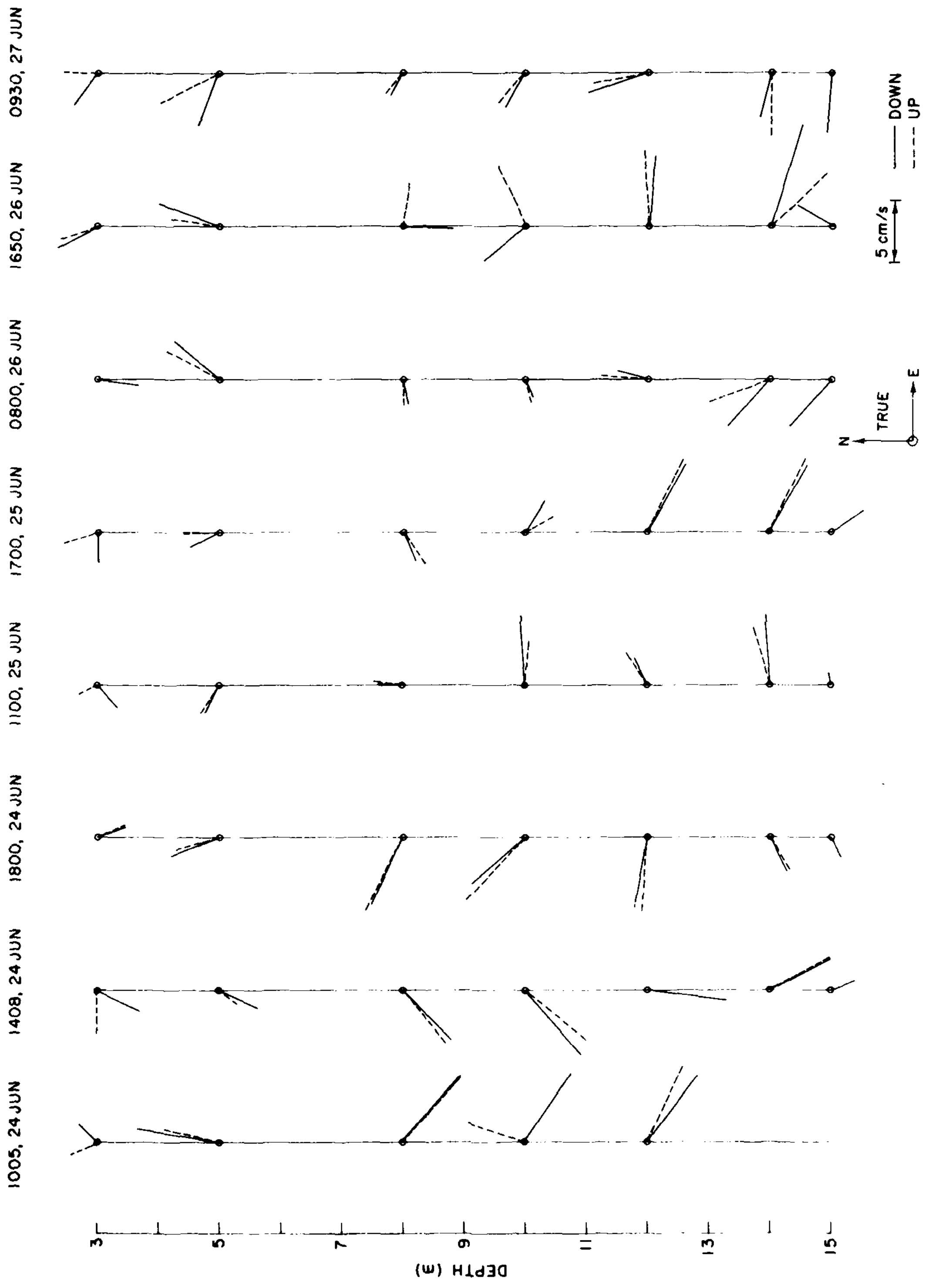

1745, 8 JUN
1830, 9 JUN
0840, 10 JUN
1335, 10 JUN
1650, 10 JUN
BEACON INTERFERENCE
0940, 11 JUN
1715, 11 JUN
1000, 12 JUN
DEPTH (m)
3
5
7
9
11
13
15
N
E
TRUE
5 cm/s
DOWN
UP


1600, 12 JUN
0950, 13 JUN
1230, 13 JUN
1605, 13 JUN
0935, 14 JUN
1605, 14 JUN
0950, 15 JUN
DEPTH (m)
3
5
7
9
11
13
15
N
TRUE
E
5 cm/s
DOWN
UP

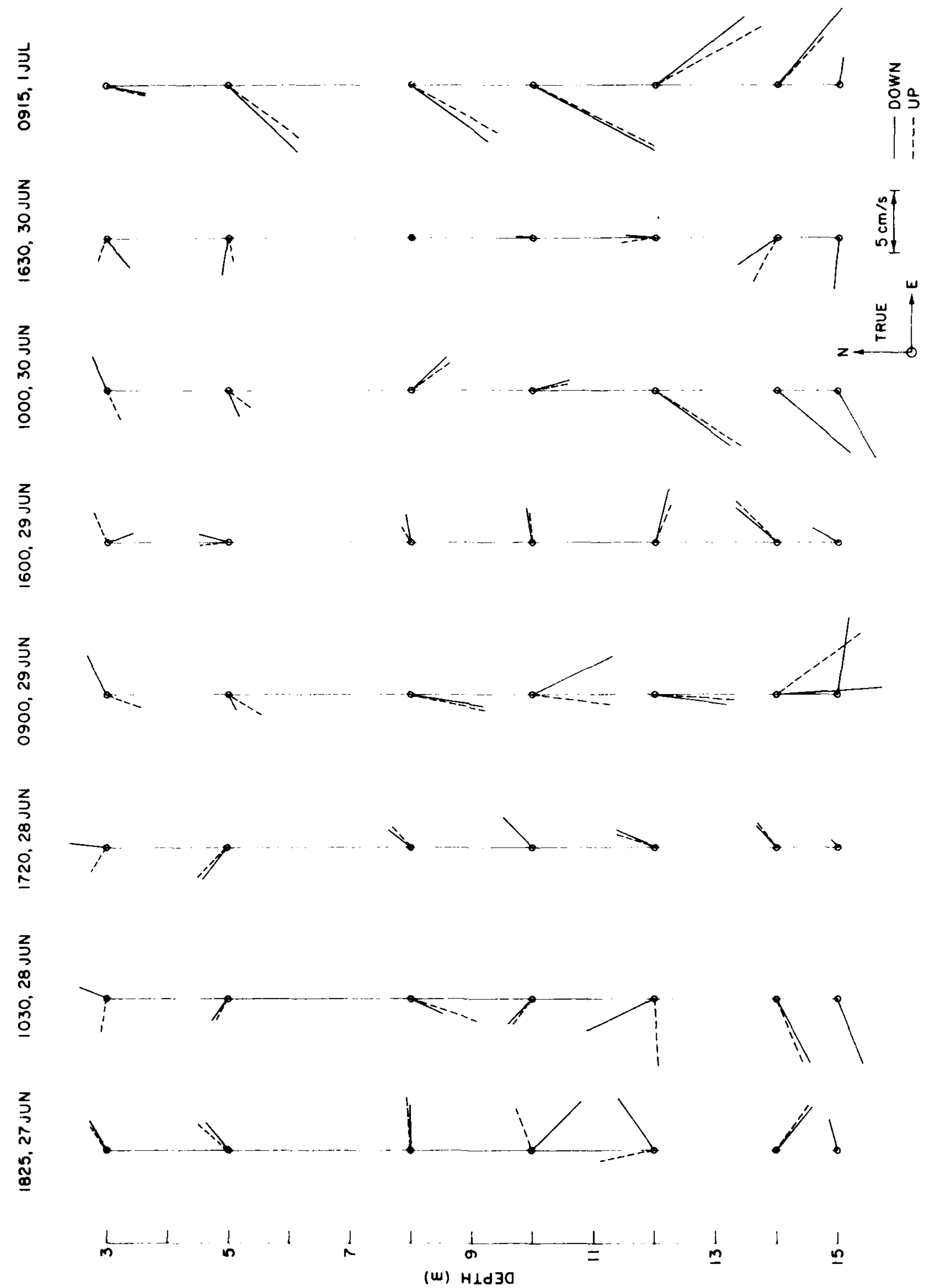

1620, 15 JUN
1145, 16 JUN
1650, 16 JUN
1900, 16 JUN
2100, 16 JUN
0840, 17 JUN
2125, 17 JUN
DEPTH (m)
3
5
7
9
11
13
15
5 cm/s
DOWN
UP
TRUE
N
E


1000, 18 JUN
1045, 19 JUN
1730, 19 JUN
0730, 20 JUN
1700, 20 JUN
1200, 21 JUN
DEPTH (m)
3
5
7
9
11
13
15
TRUE
N
E
5 cm/s
DOWN
UP

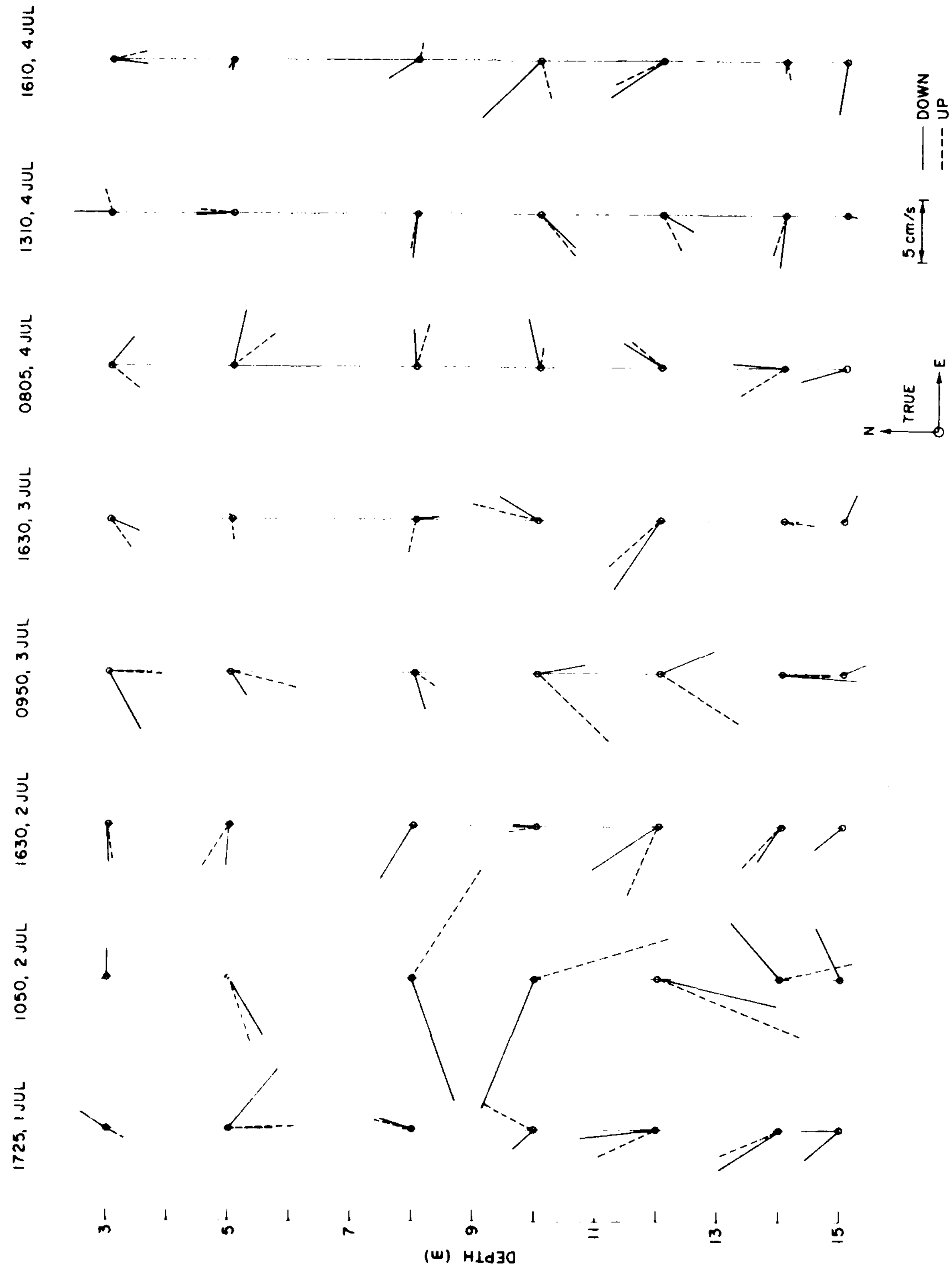

1700, 21 JUN
0930, 22 JUN
1630, 22 JUN
0835, 23 JUN
1720, 23 JUN
2005, 23 JUN
0005, 24 JUN
0605, 24 JUN
DEPTH (m)
3
5
7
9
11
13
15
TRUE
N
E
5 cm/s
DOWN
UP

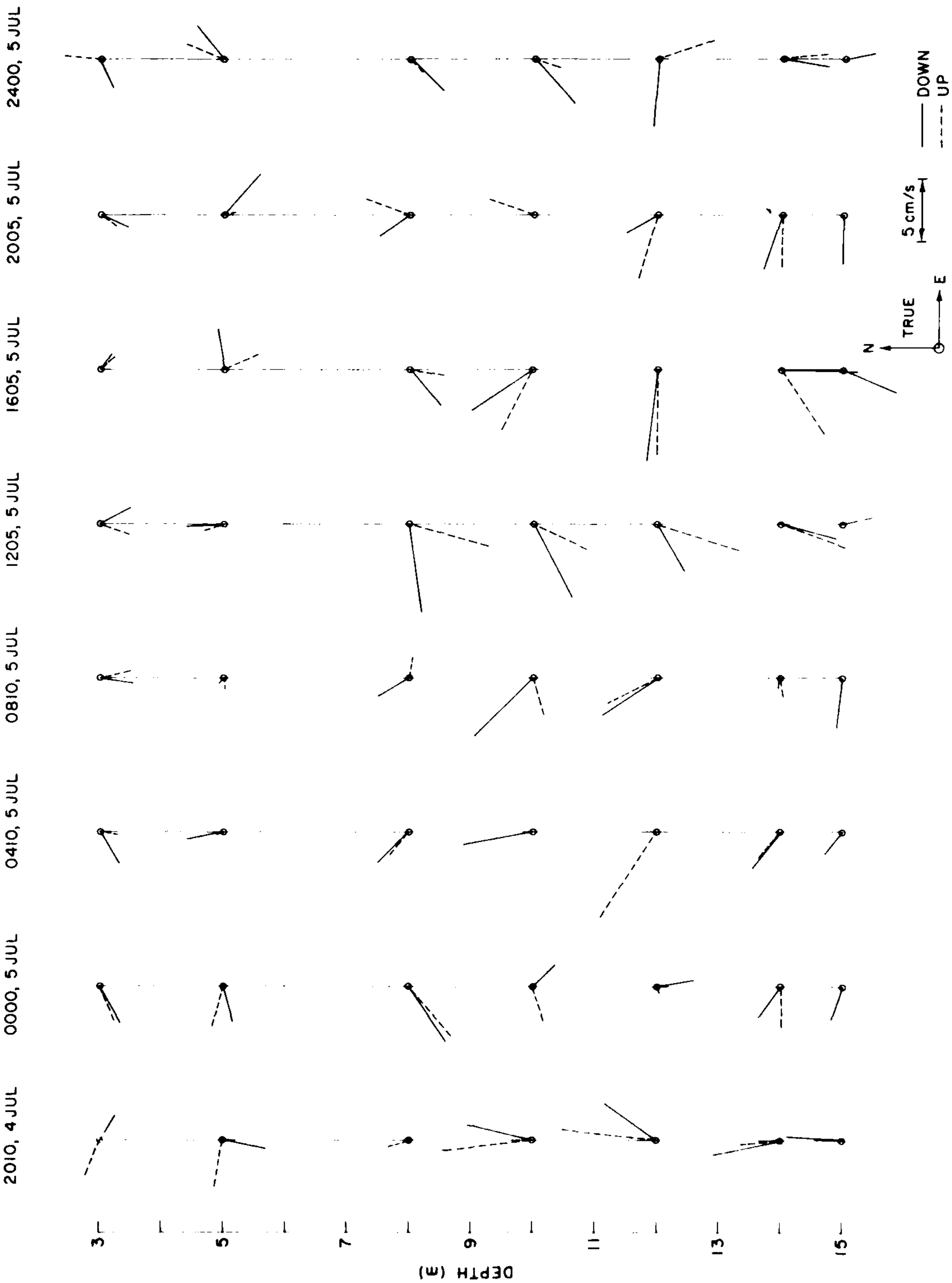


0930, 27 JUN
1650, 26 JUN
0800, 26 JUN
1700, 25 JUN
1100, 25 JUN
1800, 24 JUN
1408, 24 JUN
1005, 24 JUN
DEPTH (m)
3
5
7
9
11
13
15
5 cm/s
TRUE
N
E
DOWN
UP

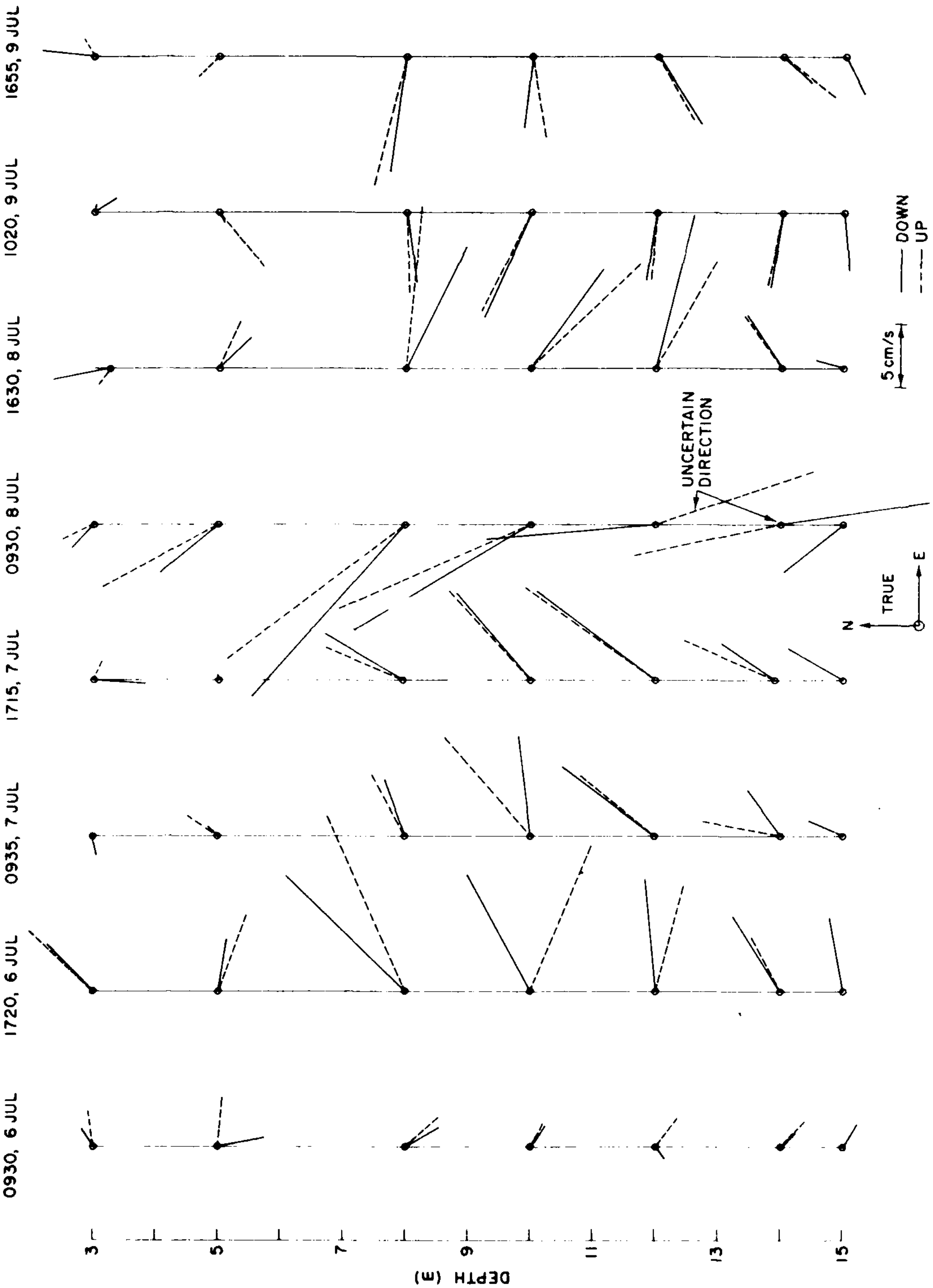


0915, 1 JUL
1630, 30 JUN
1000, 30 JUN
1600, 29 JUN
0900, 29 JUN
1720, 28 JUN
1030, 28 JUN
1825, 27 JUN
DEPTH (m)
3
5
7
9
11
13
15
TRUE
N
E
5 cm/s
DOWN
UP

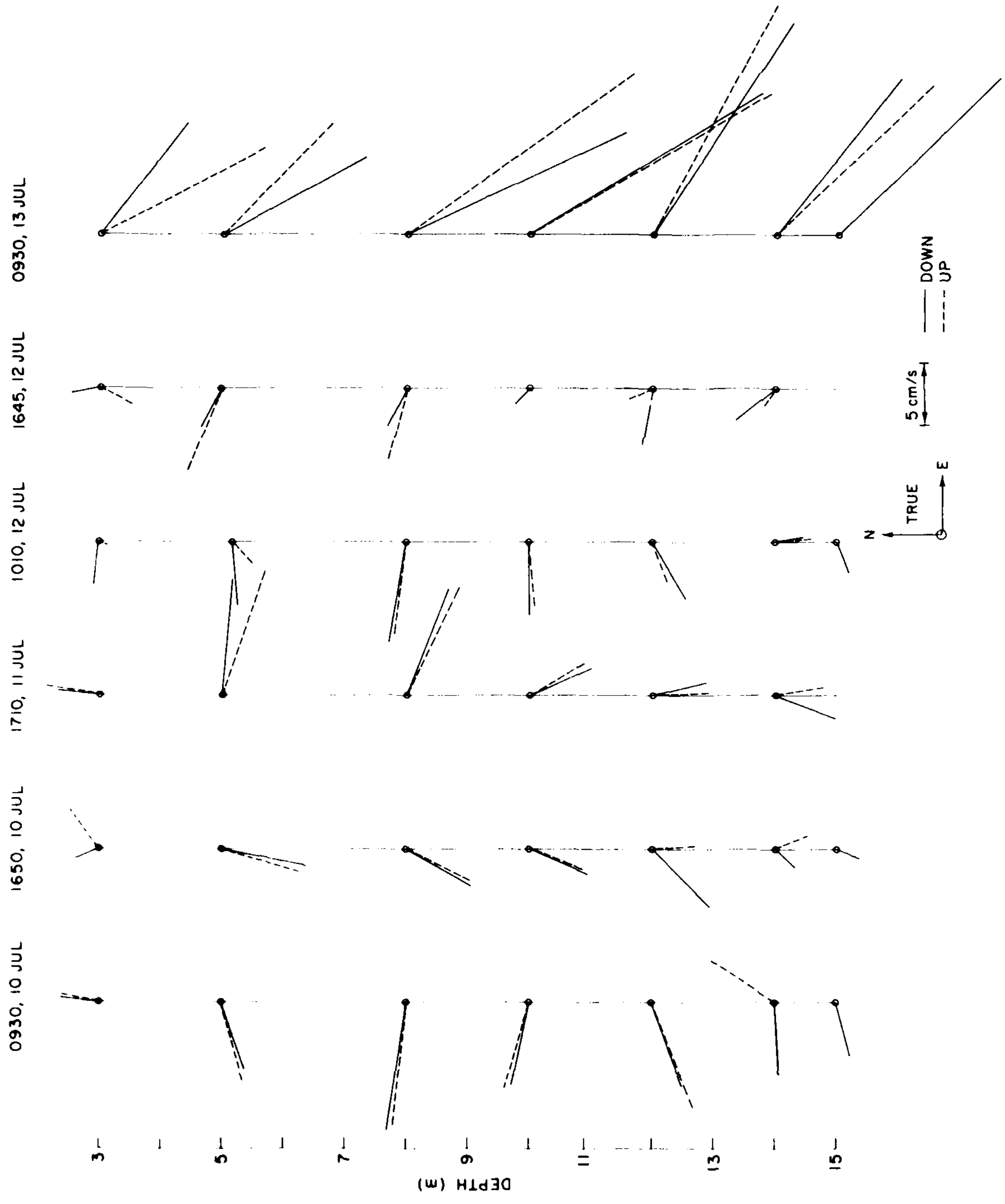

1725, 1 JUL
1050, 2 JUL
1630, 2 JUL
0950, 3 JUL
1630, 3 JUL
0805, 4 JUL
1310, 4 JUL
1610, 4 JUL
DEPTH (m)
3
5
7
9
11
13
15
N
TRUE
E
5 cm/s
DOWN
UP



2010, 4 JUL
0000, 5 JUL
0410, 5 JUL
0810, 5 JUL
1205, 5 JUL
1605, 5 JUL
2005, 5 JUL
2400, 5 JUL
DEPTH (m)
3
5
7
9
11
13
15
N
E
TRUE
5 cm/s
DOWN
UP



0930, 6 JUL
1720, 6 JUL
0935, 7 JUL
1715, 7 JUL
0930, 8 JUL
1630, 8 JUL
1020, 9 JUL
1655, 9 JUL
UNCERTAIN DIRECTION
DOWN
UP
5 cm/s
TRUE
N
E
DEPTH (m)
3
5
7
9
11
13
15


0930, 10 JUL
1650, 10 JUL
1710, 11 JUL
1010, 12 JUL
1645, 12 JUL
0930, 13 JUL
DEPTH (m)
3
5
7
9
11
13
15
TRUE
N
E
5 cm/s
DOWN
UP

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Oceanographic measurements were made in the Chukchi Sea along the Alaskan coast and at an ice camp in the shore-fast ice northeast of Barrow to study the water exchange along the coast and the influence of the Barrow Canyon. Phenomena discussed include solar warming in the shallows, the drainage of high-salinity water through the Barrow Canyon into the Arctic Ocean, and the counterflow of warmer water from the temperature-maximum layer of the ocean onto the shelf.

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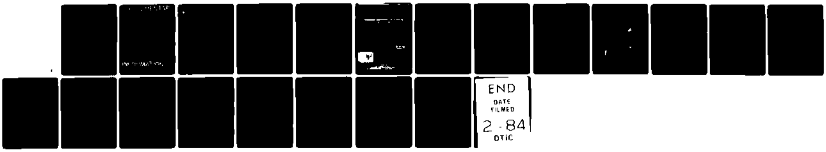

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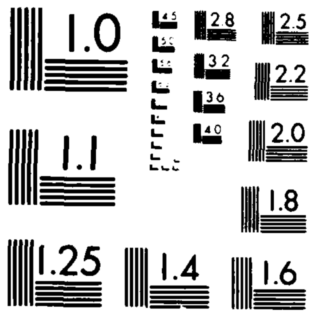

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The enclosed pages are corrected versions of the cover, title page, and pp. 26, B1, B4, B5, C1, C2, C3, C4 and C5 in APL-UW 7824. The corrections to the text consist of the addition of some isothermals that were omitted in a temperature station and changes in the temperature scale for a few profiles in the appendices.

Please remove the erroneous pages and replace them with the corrected ones, using the enclosed T-comb.

We apologize for the errors and thank you for your trouble in making the changes.

Gerald R Garrison

Gerald R. Garrison
Principal Physicist

1013 Northeast Fortieth Street

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Oceanographic Measurements in the Chukchi Sea

April – August 1977

by G.R. Garrison
M.L. Welch
J.T. Shaw

APL-UW 7824
September 1979

Applied Physics Laboratory University of Washington
Seattle, Washington 98105

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comparison with the other sections. Figure 17 shows the presence of warm, saline Atlantic water at depth and a large accumulation of cold drainage from the Chukchi Sea at 135 to 185 m. Above this, a new, cold layer at 45 to 110 m with a salinity of 32.8‰ has formed. This new layer must be a more recent movement of Chukchi Sea water into the Arctic Ocean.

July CTD Profiles off the Coast

Oceanographic conditions off Pt. Barrow were checked again in mid-July (see map in Figure 18 and Appendix C). Figure 19 shows the sections for Line B to the northeast along with station 521 from the drifting ice camp.

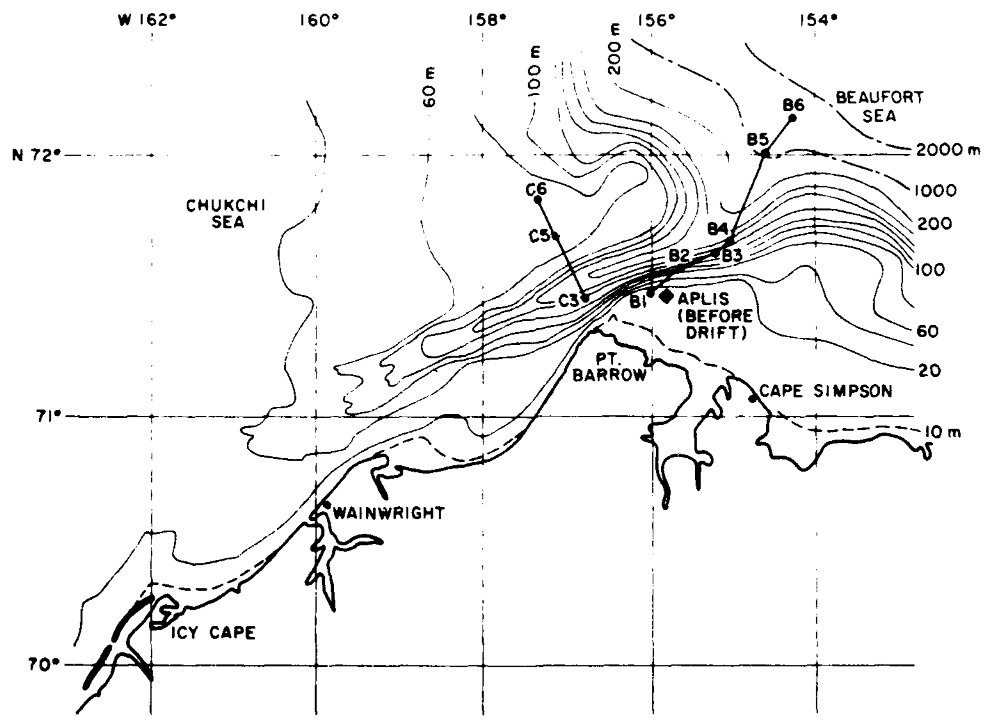


Figure 18. Location of stations for the July survey.

Station B2 contains a pocket of very warm water (-1.0°C) which is the forefront of the intrusion from Bering Strait, which became as warm as 7°C in this vicinity on 5 August. There now appear to be two layers of uniform water, one with T = -1.6°C and S = 32.8‰ between 50 and 70 m and one with T = -1.6°C and S = 33.6‰ between 120 and 140 m

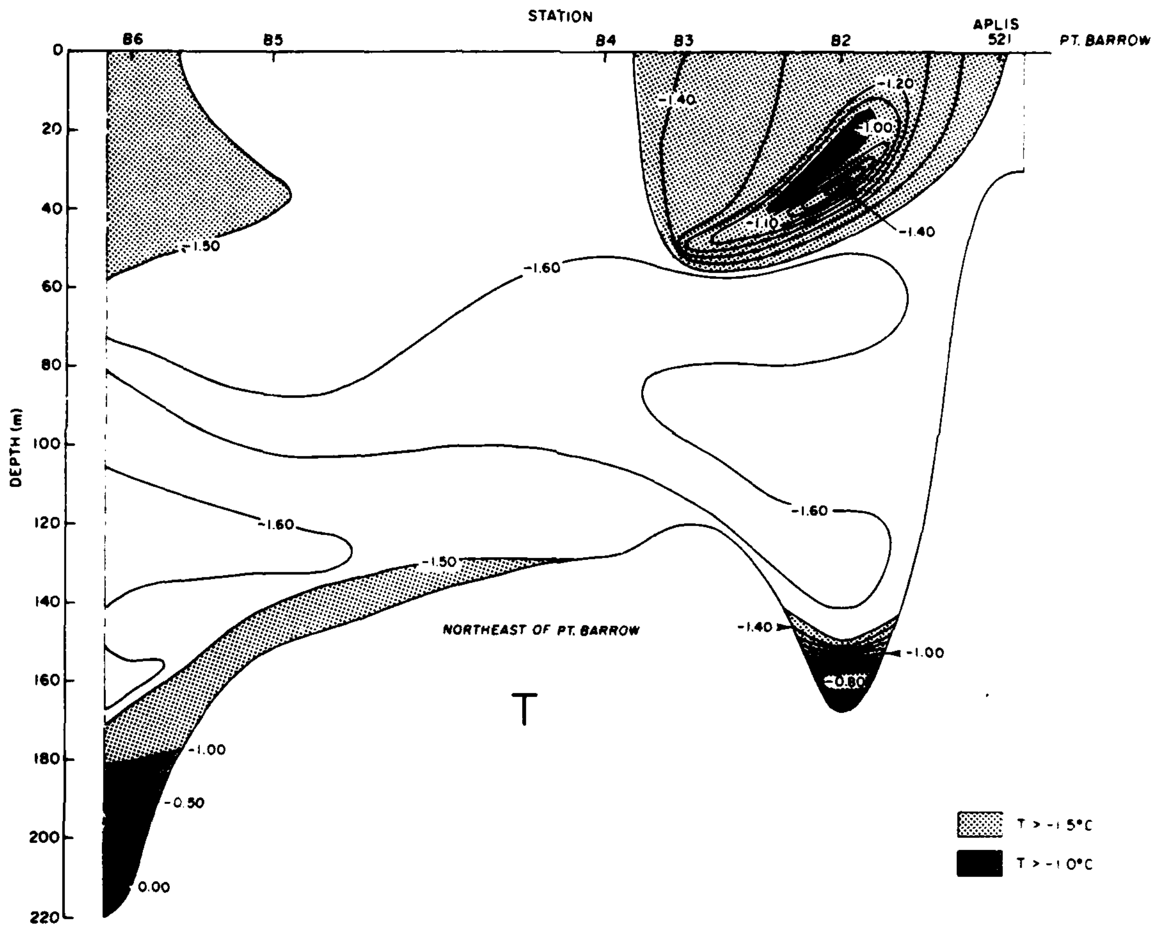
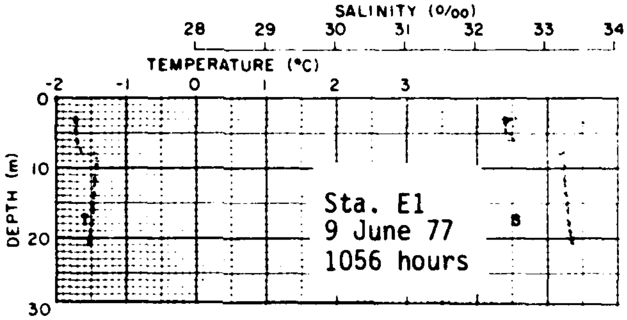
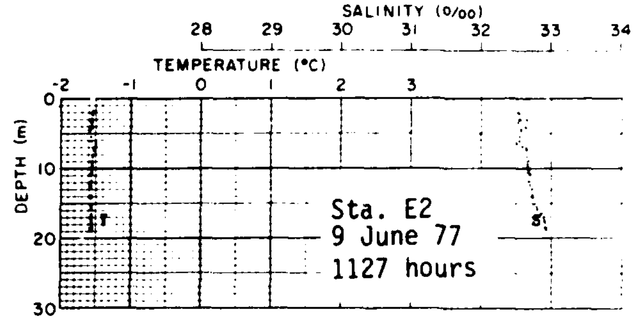
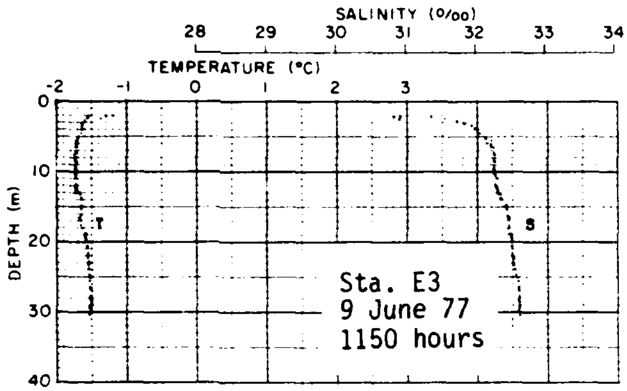
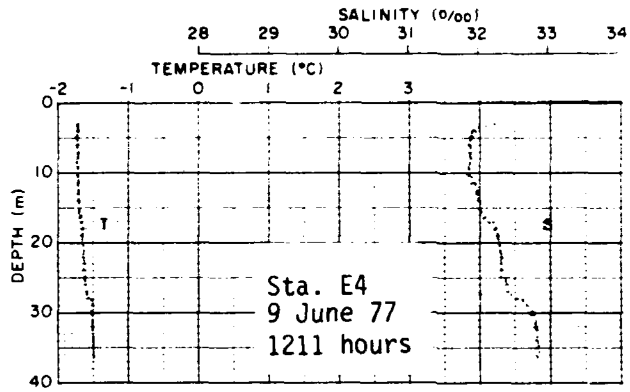


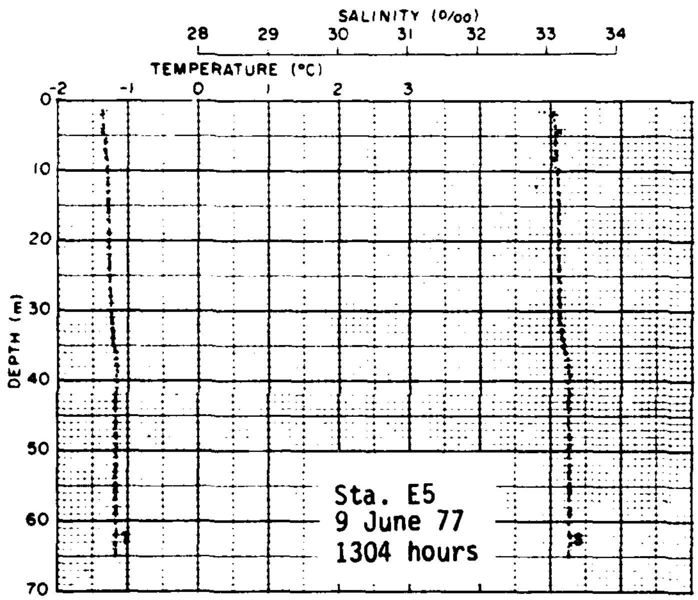
Figure 19a. Sections for Line B northeast from Pt. Barrow on 13-16 July 1977; also shown is station 521 from Ice Camp APLIS, which had just started its drift westward across the Chukchi Sea.

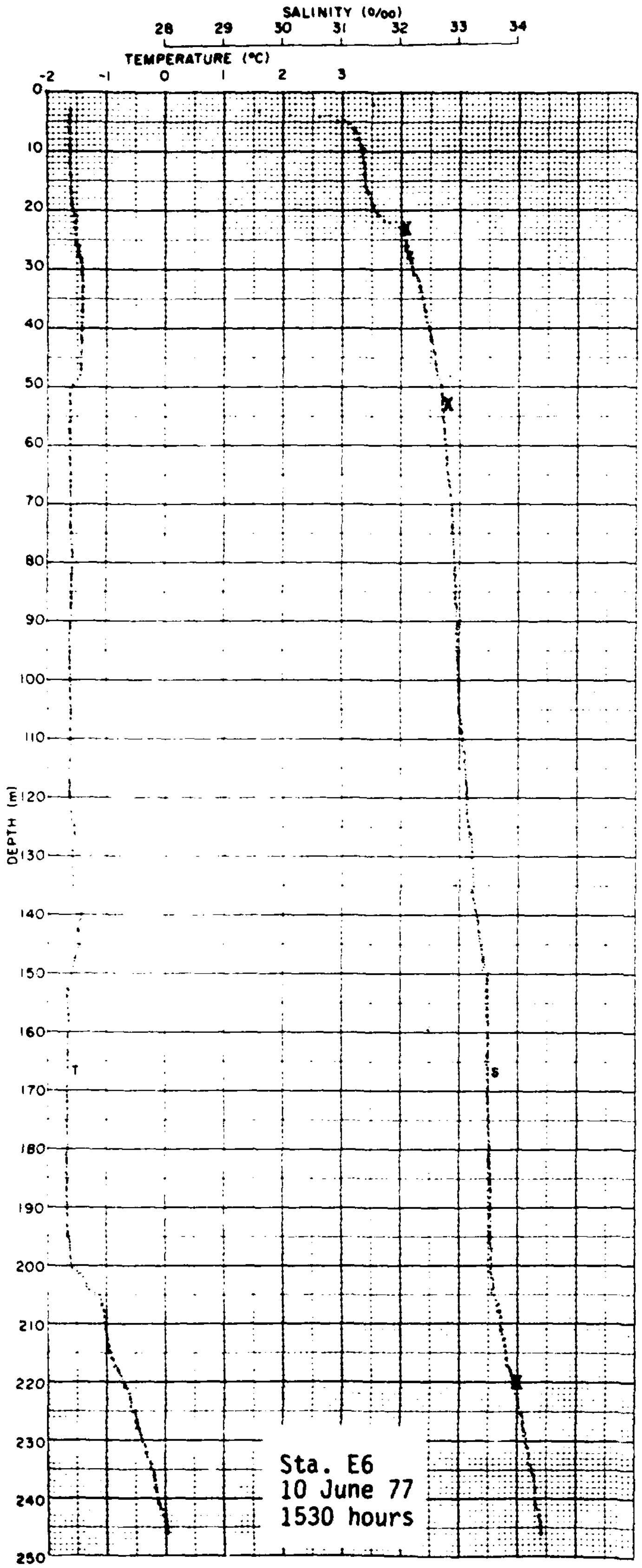

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30
T
S
Sta. E1
9 June 77
1056 hours

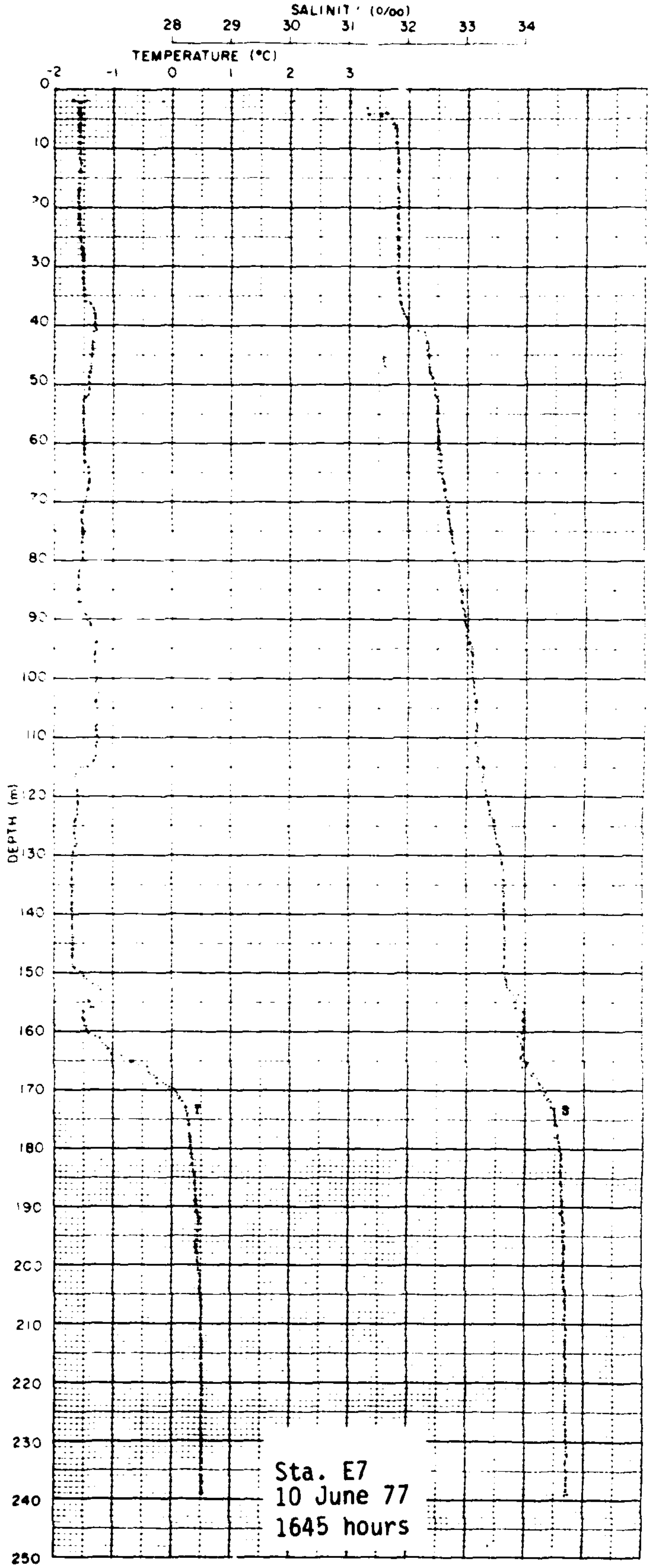

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30
T
S
Sta. E2
9 June 77
1127 hours


SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40
T
S
Sta. E3
9 June 77
1150 hours

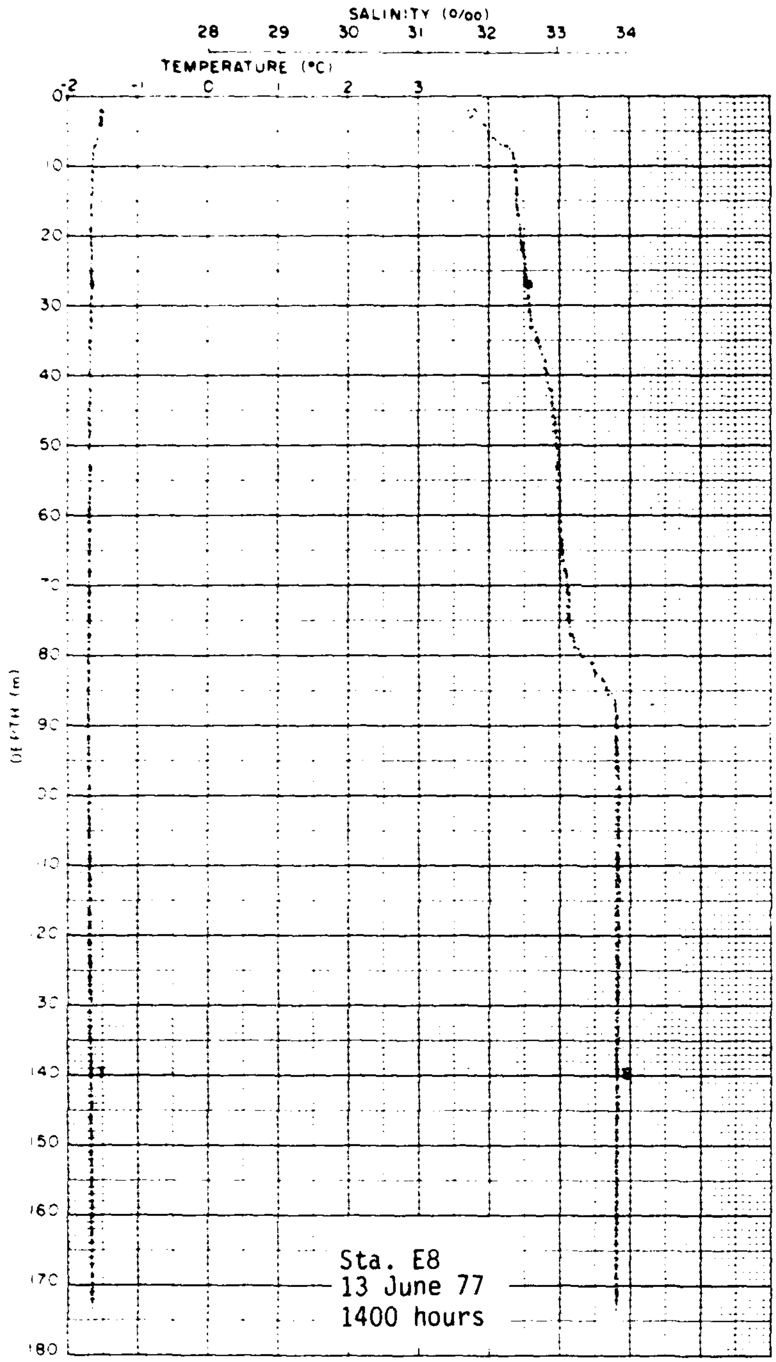

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40
T
S
Sta. E4
9 June 77
1211 hours


SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70
T
S
Sta. E5
9 June 77
1304 hours

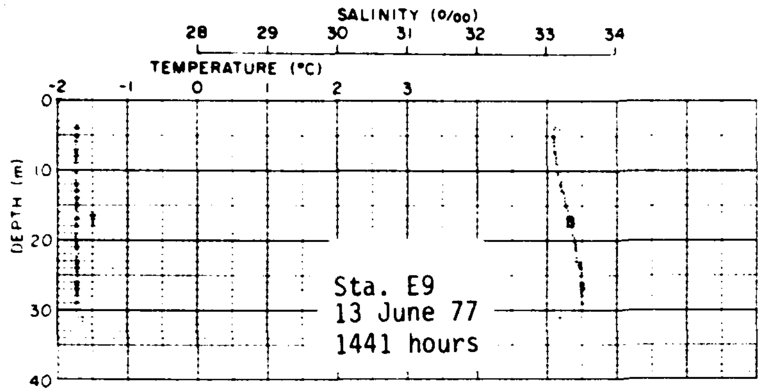

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250
T
S
Sta. E6
10 June 77
1530 hours

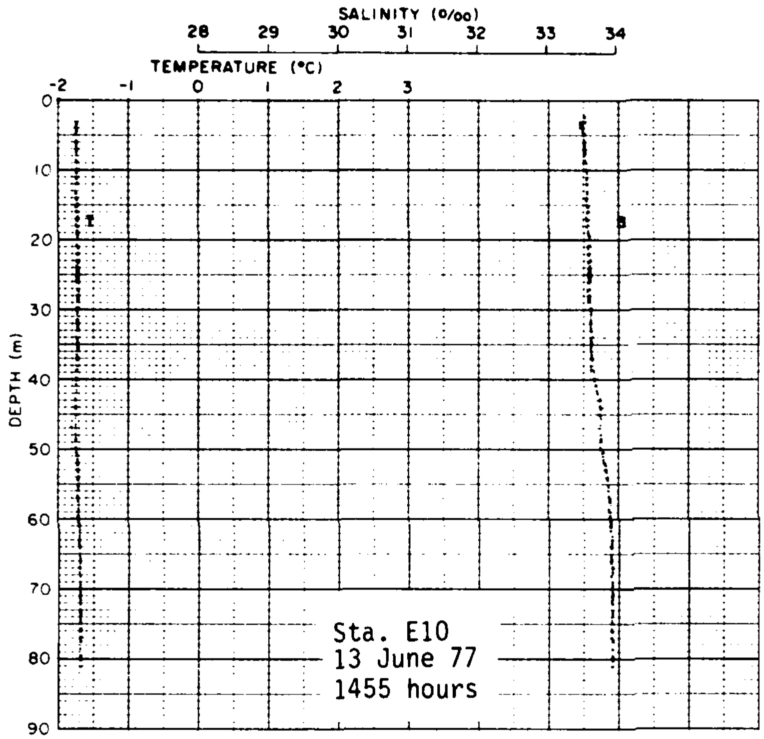

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250
T
S
Sta. E7
10 June 77
1645 hours

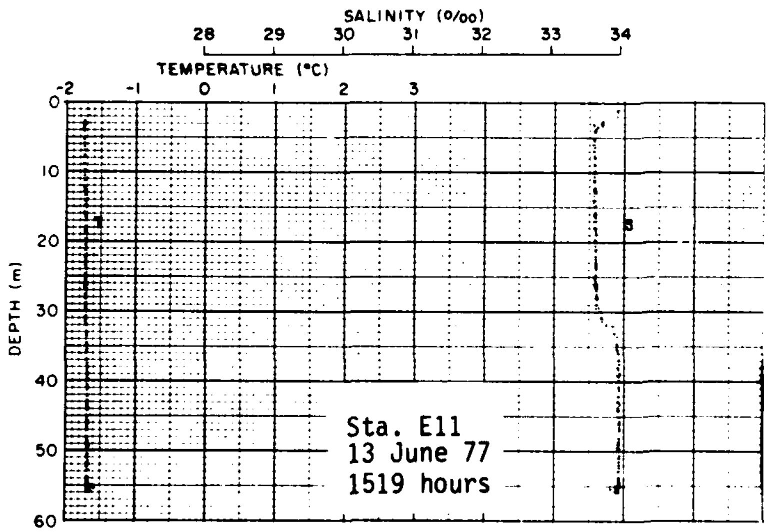
corrected October 1983

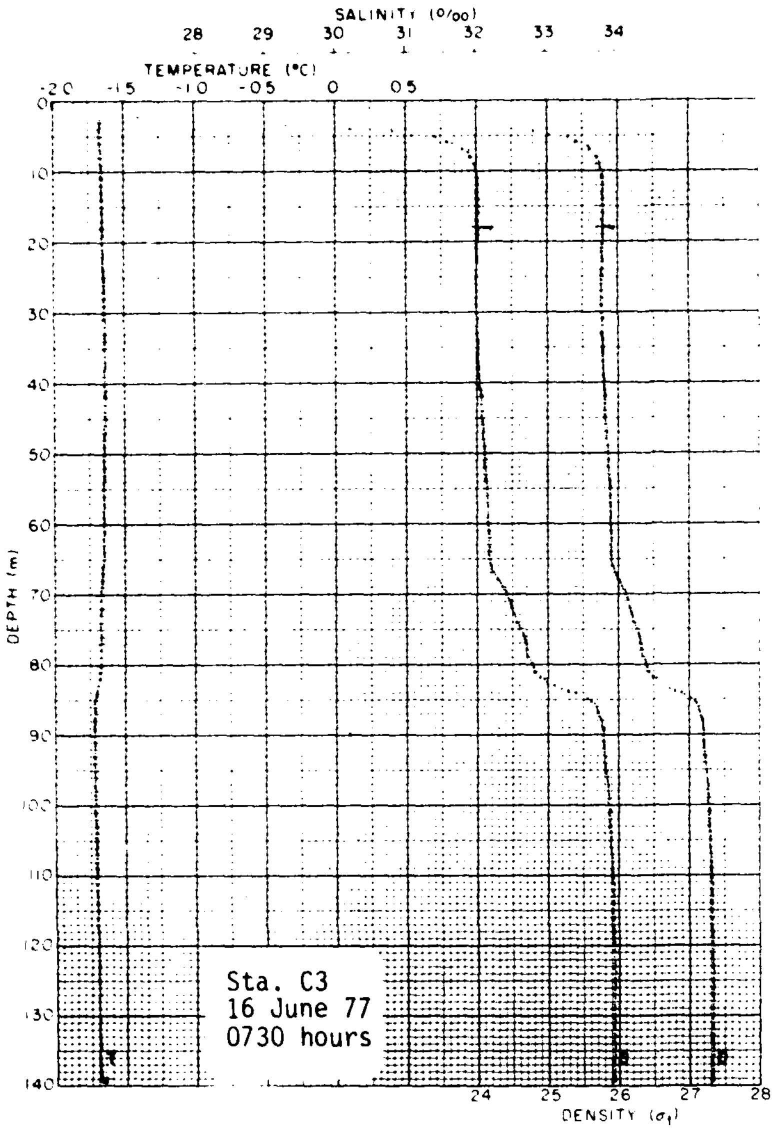


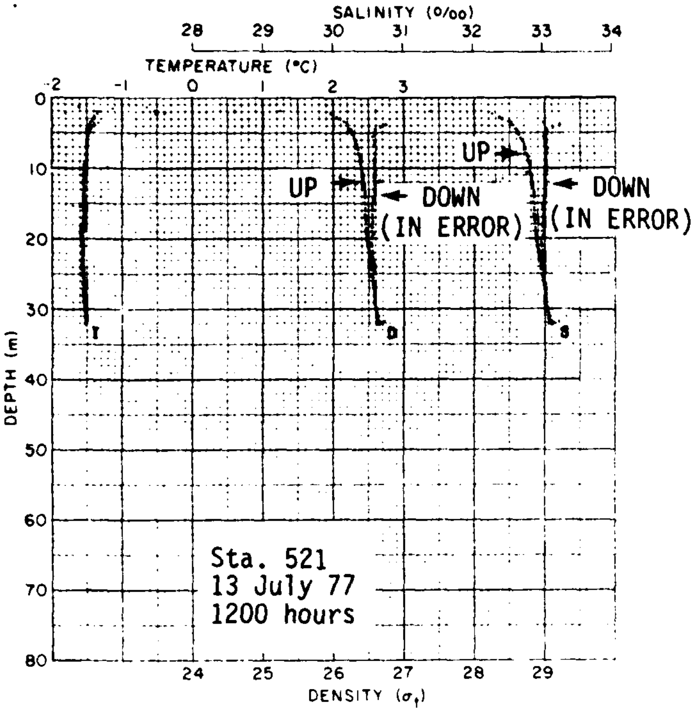
corrected October 1983

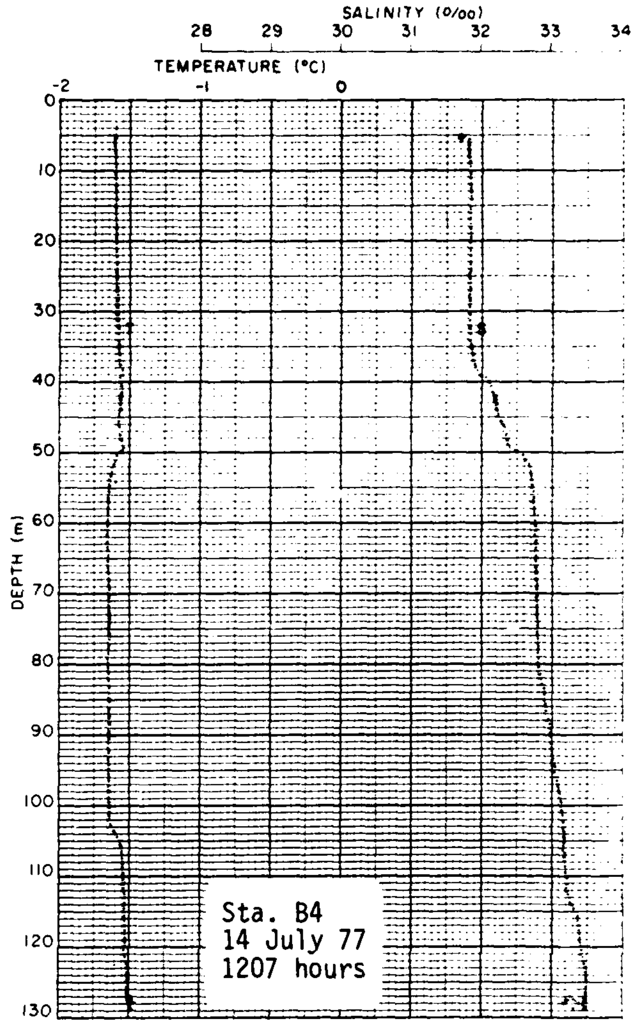


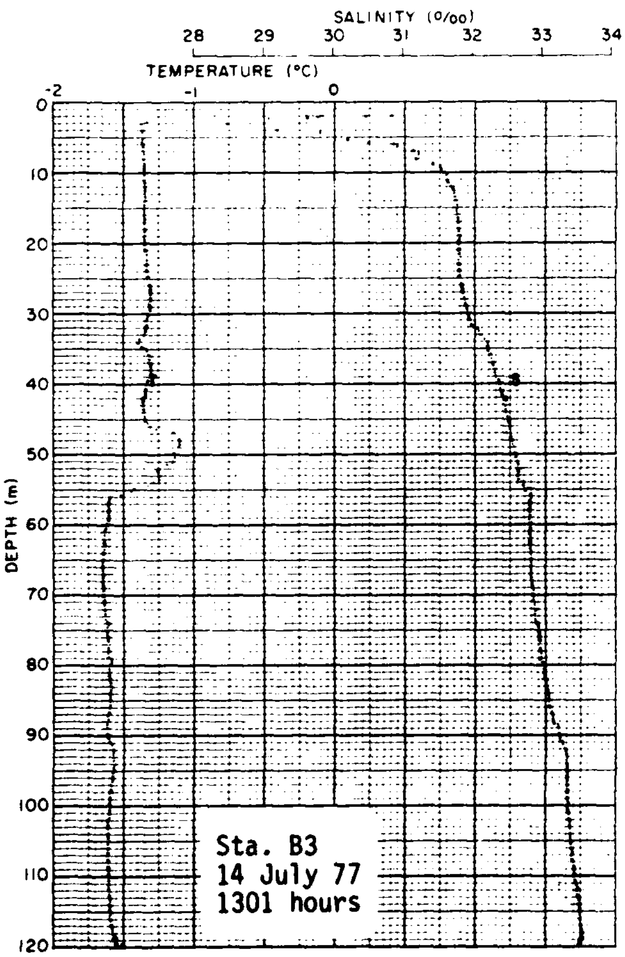




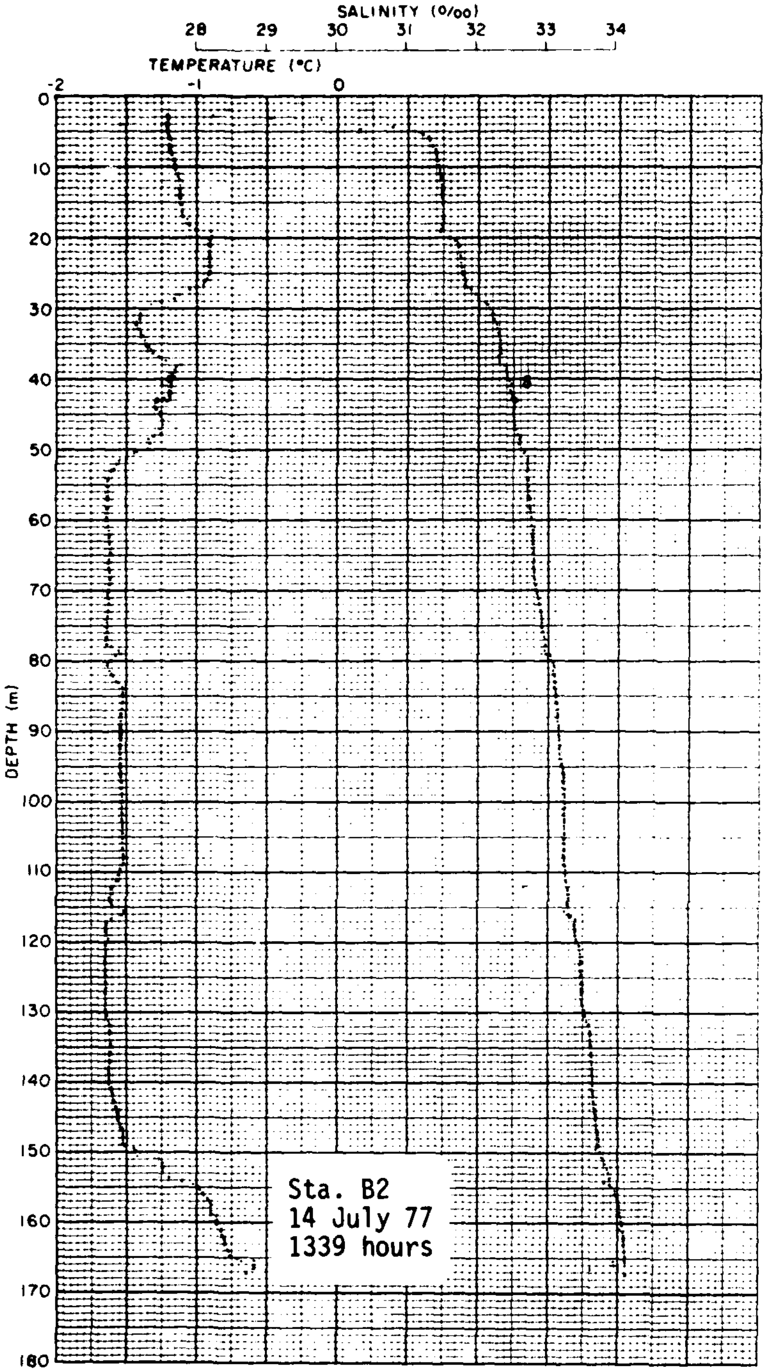

SALINITY (0/00)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2.0 -1.5 -1.0 -0.5 0 0.5
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140
Sta. C3
16 June 77
0730 hours
24 25 26 27 28
DENSITY (σ_t)


SALINITY (0/oo)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0 1 2 3
UP
DOWN
(IN ERROR)
UP
DOWN
(IN ERROR)
DEPTH (m)
0 10 20 30 40 50 60 70 80
T D S
Sta. 521
13 July 77
1200 hours
24 25 26 27 28 29
DENSITY (σ_t)

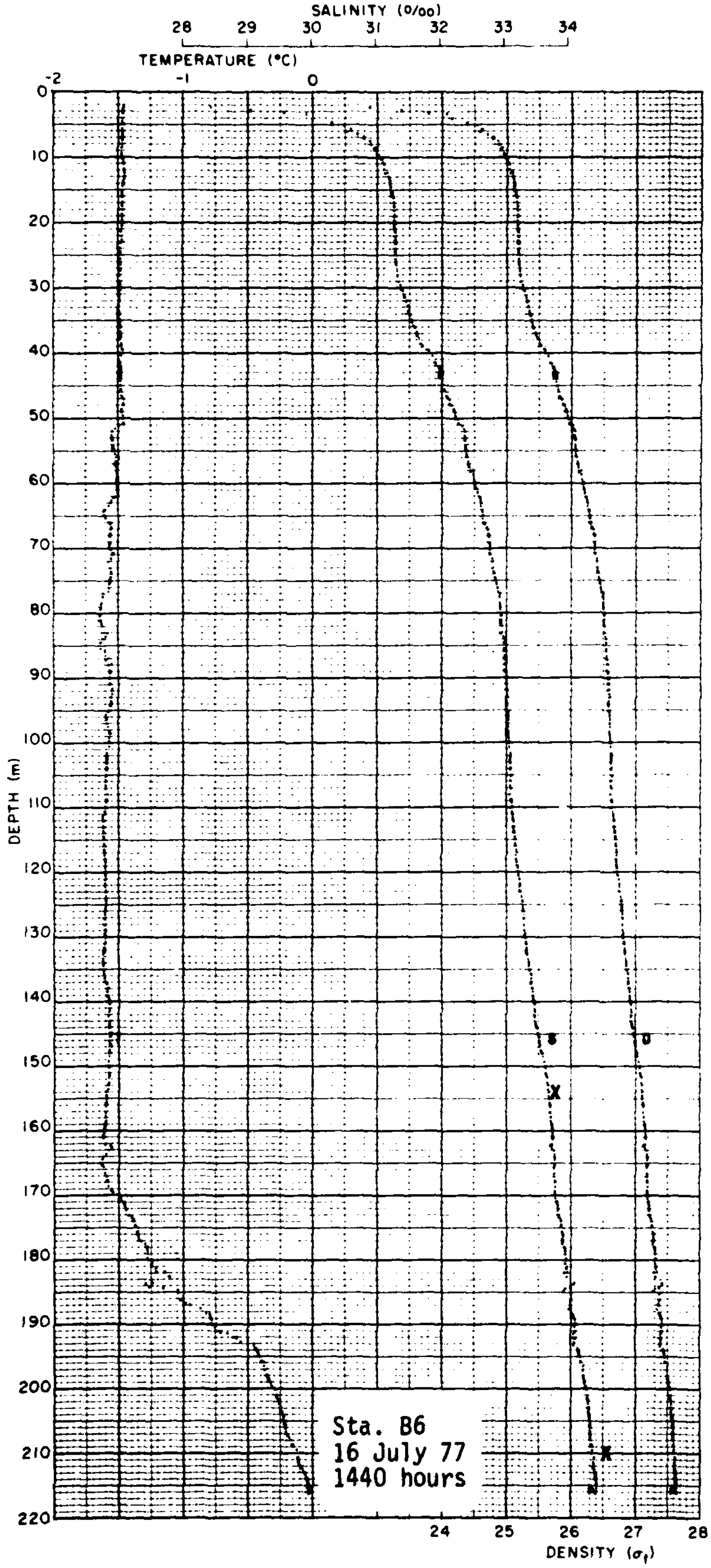

SALINITY (0/oo)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120 130
Sta. B4
14 July 77
1207 hours


SALINITY (0/oo)
28 29 30 31 32 33 34
TEMPERATURE (°C)
-2 -1 0
DEPTH (m)
0 10 20 30 40 50 60 70 80 90 100 110 120
Sta. B3
14 July 77
1301 hours

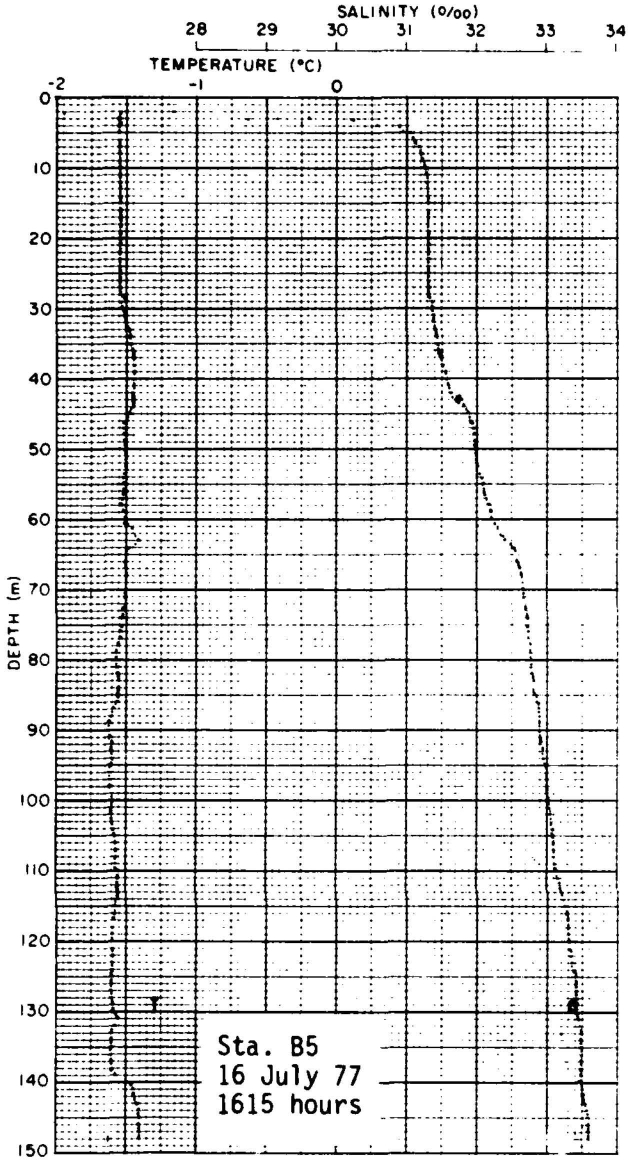
corrected October 1983

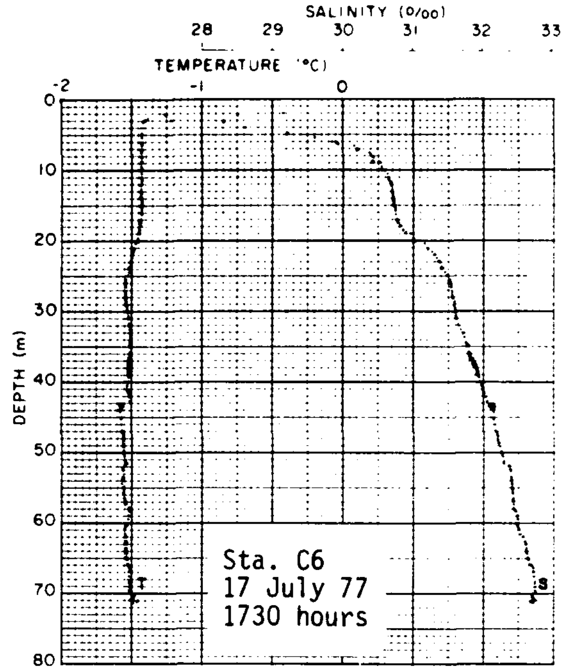


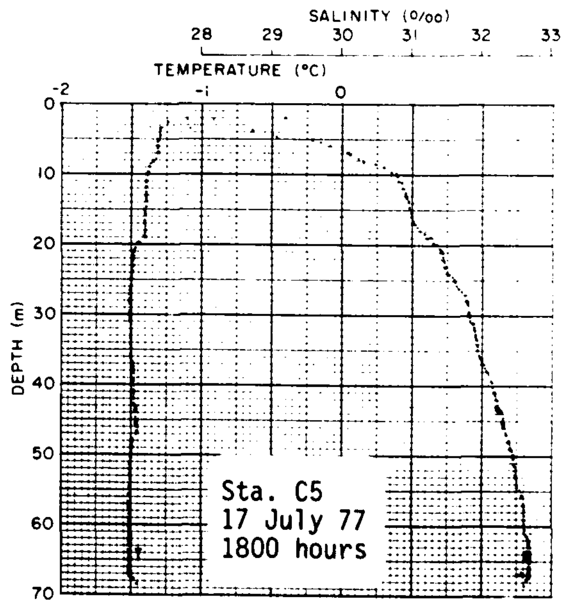
corrected October 1983



corrected October 1983







corrected October 1983